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THE TREASURES OF CUMÆ.*

By Mario Corsi.

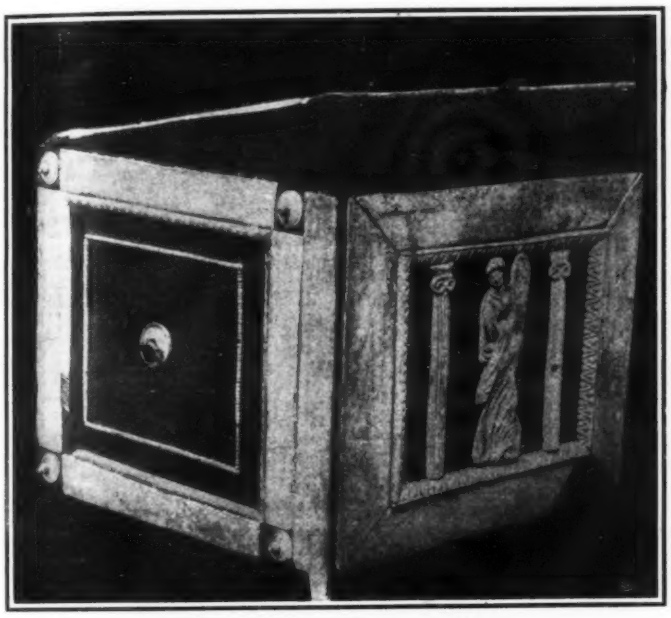
The splendid city of Cumæ, on the coast of Campania, between Pozzuoli and Capo Miseno, was one of the most celebrated of Greek colonies, and Strabo asserts that it was the most ancient Hellenic settlement in Italy. The mythological traditions of its origin extend to so remote a past that they have formed the basis of many fabulous stories. Strabo says that Cumæ was founded by colonists from Chalcis in Eubœa and Cyrene in Aeolis. The city rose rapidly to great opulence and prosperity (700-500 B. C.).

The name of Cumæ brings to mind the sibyl who is said to have lived there in a cave. This cave appears to have a real existence and to have been famous even in the historical period. Virgil thus describes it in the sixth book of the Aeneid:

> "Excisum Euboicae latus ingens rupis in antrum
> Quo lati ducunt aditus centum, ostia centum;
> Unde ruunt totidem voces, responsa Sibillae."

Which may be freely translated: "The huge flank

* Specially prepared for the Scientific American Supplement.



JEWEL CASE OF WOOD AND IVORY.

A GORGON FRIEZE.

ALTO RELIEF REPRESENTING SILENUS, EROS, AND A BACCHANTE.

ALTO RELIEF REPRESENTING BACCHUS AND A SATYR.

THE TREASURES OF CUMÆ.

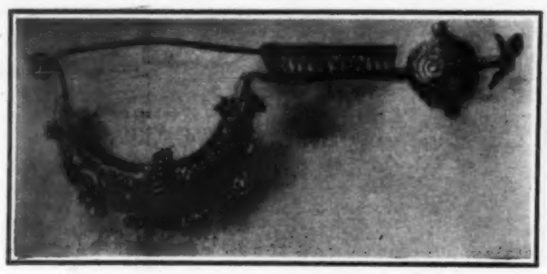
of the Euboean cliff is hollowed out into a cave with a hundred entrances and a hundred doors, whence the sibyl returns a response to every question."

Justin Martyr, who visited the cave about the middle of the second century, describes it as a great portico carved by human hands, and communicating with an obscure grotto from which issued the oracular responses of the sibyl. The walls of the sibyl's cave were destroyed with those of the city in the siege of the acropolis of Cumæ by Narses in the reign of Justinian.

Of the acropolis of Cumæ nothing now remains except the ruins of an amphitheater and fragments of the temple of giants. But the sibyl's cave, though obstructed by débris, is the objective point of all antiquarian students and amateurs.

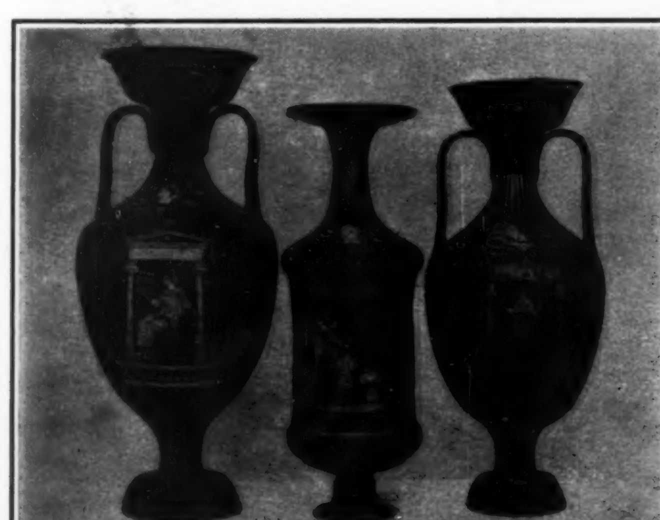
A number of professional and amateur achæologists, after a recent visit to Cumæ, decided to constitute themselves a commission for the exploration of the city which, if only because of its sibylline grotto, merits the attention of all students of history and archæology. There has been much discussion concerning the exact location of the cave, or caves, but it is now certain that there was only one, with two mouths, one of which opened near Lake Avernus. The mephitic vapors which rose from this lake suggested the fable that it was the entrance to the infernal regions. The objects that have been unearthed in this lovely spot illustrate the legends associated with it and the many striking events of which it has been the scene in its long history. Not all the treasures of Cumæ have been uncovered but recent explorations by private individuals have resulted in the discovery of many beautiful and valuable objects. Signor Ostia, of Naples, has been the most industrious and successful of the explorers and has formed in a short time, though with much labor, a very interesting collection. He was formerly in charge of the explorations directed by the Count of Syracuse and by Mr. Stevens. Among the objects collected by Signor Ostia is a remarkable gold necklace, of the Mycenean period, bearing representations of the Kores, or Daughters, of Rhea, who were personages of a pre-Hellenic religion. The pendants below these figures represent Achelous, grasping two serpents, and two of the winged Sirens, his daughters. Other objects are a casket of jewels, etc., made of wood and ivory, a magnificent terra cotta frieze representing the Gorgon Medusa with two figures in Oriental costume; a high relief showing Silenus, Eros and a bacchante; a very beautiful gold clasp; Italic vases painted with exquisite art; and a terra cotta of rare beauty, representing Bacchus returning from a nocturnal orgie preceded by a satyr.

It is the earnest desire of lovers of antiquity that all of these treasures may be acquired by the government and placed in a public museum.



GOLDEN CLASP PIN.

GOLD NECKLACE OF THE MYCENEAN PERIOD, ADORNED WITH SYMBOLS OF A PRE-HELLENIC RELIGION.



PAINTED VASES IN ITALIC STYLE.

THE TREASURES OF CUMÆ.

MENDEL'S LAW OF HEREDITY.

By Dr. Wilhelm Haacke.

At the close of the nineteenth century the science of heredity was very rich in hypotheses but exceedingly poor in systematically observed facts. Then a discovery was made which would have swept away all of these hypotheses had not many biologists become too habituated to them to give them up. Nevertheless, the discovery attracted much attention and caused no little mortification, for it was a discovery, not of a new fact of observation, but of a research published forty years ago (in 1865) in the transactions of a scientific society in Brünn, Austria, by an Augustine monk named Gregor Mendel.

Mendel was a man of science but not a scientist. He had studied in Vienna, devoting his attention chiefly to botany and meteorology, and at the Brünn polytechnic school, where he began to lecture in 1854, he taught both physics and natural history. Before this, in 1843, he had entered the Augustine monastery at Brünn, of which he became prelate in 1868 and where he died in 1884. After his elevation to the prelacy he found no time to continue his studies in heredity or give wider publicity to the results already obtained, so that the latter, having unfortunately been printed in so obscure a publication, remained almost unnoticed, and Mendel's name was not mentioned, until recently, by any of the numerous writers on heredity. Yet it may be asserted without hesitation that Mendel's essay, published in 1865, is the most important work on heredity and hybridization that has yet (to speak with due caution) come to light.

It was, very properly, reprinted in 1901 as one of Ostwald's Science Classics,* and it has already prompted many new researches, though it is still less widely known than it deserves.

In me it has aroused mingled feelings for, independently of Mendel and while even ignorant of his existence, I had deduced the same law of heredity from systematic experiments of my own, and after writing an account of my researches† I had the mortification of learning I had been anticipated by an unknown worker, forty years ago.

My experiments were made with mice, Mendel's chiefly with peas, the study of which he commenced before the publication of Darwin's "Origin of Species," and therefore without being influenced by that work.

Mendel purchased, from a number of seedsmen, peas of 34 distinct varieties, 22 of which he selected for his experiments after he had proved the constancy of their characters by two years' culture. The most striking differences between the selected varieties were the following: The ripe seed was either smooth or wrinkled, its flesh as seen through the translucent skin was yellow or green, while the skin was either white or gray brown. The white-skinned peas had white flowers, the others violet or purple flowers and reddish leaf stalks. Again, the unripe pods were either smoothly rounded or constricted between the seeds, and their color, with that of the stalks, leaf ribs, and calyx, was either green or distinctly yellow. There were differences, too, in the arrangement of the flowers. In some varieties they were axillary and distributed along the stalk, while in others they were collected into a pseudo-umbellate terminal cluster. Finally, though the healthy plants of any one variety differed little in height, the average heights of the varieties differed greatly.

Mendel always crossed two varieties which contrasted in some one character, applying pollen from each variety to the stigmas of the other. That is, he crossed smooth peas with wrinkled peas, yellow peas with green peas, varieties having gray or brown skins and colored flowers with varieties that have white skins and white flowers, smooth pods with constricted pods, green pods with yellow pods, scattered flowers with terminal flowers, and tall with short varieties.

In the offspring of these crosses one of the contrasting pair of characters combined by the cross was almost or entirely absent. Mendel calls this the "recessive" and the other the "dominant" character. The dominant characters were smooth seeds, yellow seeds, gray or brown seeds associated with colored flowers and red spotted axils, smooth pods, green pods, scattered flowers and tall plants. In respect to the shape and color of seeds the dominance of one of the contrasted characters appeared in the first year, in the seeds resulting directly from the cross-fertilization; in the other characters the dominance first became apparent in plants raised in the following year from the seeds thus produced.

But the recessive character as well as the dominant character reappeared in perfect purity in the immediate offspring of these hybrids, in which offspring the two pure characters were always represented very nearly in the ratio of 1 to 3. That is to say, in every four plants of the second generation, one exhibited the recessive and three the dominant character, no intermediate form being ever observed. For example, of 7,324 seeds of plants of the second generation, from a cross of smooth and wrinkled varieties, 5,474 were smooth and 1,850 were wrinkled, a ratio of 2.96 to 1.

The ratios of the dominant to the recessive character, as shown in the second generation for the various pairs of characters, were the following:

Smooth seed to wrinkled seed as	2.96 to 1
Yellow flesh to green flesh as	3.01 to 1
Gray or brown skin with colored flowers to white skin with white flowers as	3.15 to 1
Smooth pod to constricted pod as	2.95 to 1
Green pod to yellow pod as	2.82 to 1
Scattered flowers to terminal flowers as	3.14 to 1
Tall plant to short plant as	2.98 to 1

In every case the ratio, taken to the nearest whole number, is 3 to 1.

But Mendel was not satisfied with this very definite and surprising result. He continued the cultures, and obtained from the third and subsequent generations equally definite results, which may be stated as follows: Those plants of the second generation after the cross which showed the recessive character, and all of their descendants through all subsequent generations, proved themselves to be pure bred with respect to that character by remaining perfectly true to type. But only one-third of the "grandchildren," or plants of the second generation from the cross which showed the dominant character, produced only descendants that remained true to that dominant type through all subsequent generations, while the remaining two-thirds produced, in the next generation, plants of the recessive type as well as plants of the dominant type. In other words, one-fourth of the "grandchildren" were purely recessive, one-fourth purely dominant, while the remaining two-fourths—though showing the dominant character themselves—proved that they were not of pure breed, but were hybrids in respect to the pair of characters in question, by producing progeny of both types.

And the immediate progeny of these hybrids among the "grandchildren" obeyed the same law of numerical proportion of types that governed the "grandchildren" themselves, the dominant and recessive characters being again represented in the ratio of 3 to 1. Here, too, all of the recessive but only one-third of the dominants proved themselves of pure breed by transmitting their respective characters to

* Klassiker der Exakten Wissenschaften, No. 121.
† Published in Roux's Archiv für Entwickelungsmechanik, Band xxi., 1906.

all their descendants, while the rest proved themselves to be really hybrids by producing descendants of both types.

And so on indefinitely, according to the law that plants which are hybrids in respect to a particular pair of contrasting characters produce seeds, half of which grow into hybrid plants, one-fourth into pure dominants and one-fourth into pure recessives, both of which pure breeds transmit their respective types to *all* of their descendants.

Purity of breed or type, in this connection, always refers to a single character, for Mendel has proved that many of the characters of peas are inherited independently of each other. White flowers are always associated with white seed coats, but when Mendel crossed a variety with smooth seeds and yellow flesh on a variety with unwrinkled seeds and green flesh, he obtained with the second generation from the cross, four sorts of peas; round yellow, wrinkled yellow, round green, and wrinkled green. This variegated progeny introduces an apparent complication into the law of heredity but the explanation is very simple. Before I give it, however, I will describe my experiments with mice.

I distinguish two principal varieties of cage mice, the common or running mouse and the Japanese waltzing mouse, so named from its whirling movements and unsteady gait. Either variety may be pure white, or self-colored, or mottled with one color and white. The skin and fur may contain yellow, black, or gray pigment, the last being an intimate mixture of the other two. The color depends upon both the character and the quantity of the pigment. I distinguish ashen, brown, black, fawn, yellow, grayish yellow, yellowish gray, and gray, in addition to white, which is due to entire absence of pigment. I make three grades of saturation with pigment and two of the proportion of white in mottled mice. In this way I distinguish 25 varieties of running and 25 of waltzing mice, or 50 in all.

Now I have found that gait, marking, saturation with pigment, capacity for pigment, and nature of pigment are inherited independently of each other, that dominant and recessive characters can be distinguished in mice, and that these characters occur in the same proportion as in Mendel's peas, if a sufficiently large number of individuals is considered.

Mendel's law of heredity applies to mice as well as to peas and hence it probably applies to the varieties of every animal and vegetable species.

I prefer to state the law as follows: Every organism possesses a number of characters, each of which is inherited independently of the others. The fertilized ovum of every organism that is propagated sexually contains a special portion of formative material for each character of the organism into which it will develop. Half of this material is derived from the male and half from the female parent. The two halves unite when the ovum is fertilized by the male cell but separate when the organism developed from the fertilized ovum produces reproductive cells in turn.

Hence each half of the formative material in question is transmitted unmixed from generation to generation, independently of the other half and also independently of the material which determines other characters.

An example will make this clear. Denoting by *P* the material that determines the deposition of pigment in the skin of a mouse, I will designate by P_1 the modification of this material that favors and by P_2 the modification that prevents such deposition. Then a pure breed of colored mice results from the combination P_1P_1, and a pure breed of mice from P_2P_2.

Now if a colored mouse is mated with a white mouse the offspring results from the combination P_1P_2. The young mice are colored because of the dominance of P_1, but each of them, at maturity, produces reproductive cells containing P_1 only and an equal number of reproductive cells containing P_2 only, because the halves of the combination separate in the formation of reproductive cells. This is true whether the animal is male or female. Hence the mating of two of these colored hybrids involves four possible conjugations of reproductive cells: P_1 male with P_1 female, P_1 male with P_2 female, P_2 male with P_1 female, and P_2 male with P_2 female, all of which are equally probable. Consequently, in a large number of offspring produced by such matings the combinations P_1P_2, P_1P_1, and P_2P_2 will occur with the relative frequencies 2, 1, 1. In other words, half of the progeny will be essentially hybrids like their parents, one-fourth will be colored mice of pure (self-perpetuating) strain, and one-fourth will be white mice of equally pure strain.

This theory appears to be confirmed by my experiments with mice, of which I bred more than 3,000, and Mendel's experiments with peas. Several botanists have proved that certain other plants obey Mendel's law, and Arnold Lang, of Zurich, has shown that it applies also to snails. The English biologist, Darbishire, has misinterpreted the results of his own experiments with mice and therefore rejects Mendel's law, but his results, as I interpret them, confirm the law.

This newly-discovered law of heredity is already beginning to bring about a revolution in biological theories and it cannot fail to influence the practice of breeders as well, for it shows how easily new permanent varieties of animals and plants can be produced by skillful crossing and artificial sexual selection. For example, a character of an existing variety can be converted into an analogous but contrasting character derived from another variety without affecting any of the other characters of the plant or animal. It will be necessary first, of course, to ascertain in each instance which characters are inherited independently of others. This problem has already been attacked by the formation in February, 1906, of the German Breeders' Society, one of whose objects is the study of the phenomena of heredity. But in view of the time, money and equipment required, aid should be given by the government, and it must be remembered that only thoroughly systematic and scientific researches can give results of either scientific or practical value. —Translated for the SCIENTIFIC AMERICAN from Die Umschau.

THE SIBYL'S CAVE AT CUMÆ.

THE ACROPOLIS OF CUMÆ.

THE TREASURES OF CUMÆ.

THE EFFECT OF COMMERCIAL FERTILIZERS.

By E. B. VORHEES.

WHAT are, therefore, some of the questions that now confront us, as chemists, and the solutions of which have so important a bearing upon the agricultural progress, and consequent true development and utilization of our resources? One of the first questions which, it seems to me, is important, is the question of the ultimate effect of the continued use of commercial fertilizers. The problem is before us now. Frequently, questions come which we cannot answer. For example, the farmer who has used large quantities of commercial fertilizers for the growing of early potatoes, cabbage, celery, or any other crop of this class, states that his crops do not seem to respond to these applications in the same degree as formerly, and that increasing quantities are required to secure profitable results, notwithstanding calculations show a great accumulation of these elements in the soil. Furthermore, he has also learned that other crops in the rotation do not thrive as well as formerly. He can distinguish no marked difference in the character of his soil, but clover, alfalfa, beans, or peas do not grow as well as formerly. He is unable by a judicious seeding of crops, for supplying vegetable matter, to secure a normal and healthy growth. Hence, questions as to the cause of the trouble are asked of the chemist, but cannot be answered fully by him. He is unable to point out the cause of the difficulty; he may suggest that the result is due to changes in the physical character of the soil, due to the undue removal of one or more elements, not included in the commercial fertilizers applied; to the destruction of certain forms of bacteria, or to the development of plant poisons in the soil, but he has nothing definite to offer. Hence, it seems to me that this is an important problem for our chemists to solve, and which must be solved if we are to make progress, and to give to the farmer what he is justly entitled to, for have we not advised him, by our teachings, to follow the methods which he is now using, without warning as to the possible effect of his work? This condition of affairs applies more particularly to those sections of our country where the lands were not originally abundantly supplied with the essential elements. The areas now requiring large applications of commercial fertilizers are fortunately limited in this rich country of ours, yet they are so located in reference to markets as to make them increasingly valuable. In the richer sections, too, farmers are learning, by sad experience, that the productivity of their soils is not as great as formerly; they know now that their methods of farming have been wasteful, and that the available constituents have, in large part, been removed, yet they have been taught by the chemists that there exists in their soils such an abundance of the minerals as to make it possible to grow maximum crops for centuries, though they are unable, with the knowledge now available to them, to obtain as large crops as formerly, without the application of fertilizers. These areas are so large that it is manifestly impossible, with the supplies of material in sight, to provide artificial fertilizers, in order to meet the situation; neither is such a practice warranted, with the vast quantities now present in the surface and subsoils. The chemist advises that it is probably a question of imperfect chemical, or physical, or bacteriological conditions of the soil, or of all these combined. The chemist should not deal in probabilities; he should be able to give positive advice. Hence, this is a problem for the chemist, and one worthy of his best thought—he must find out what the cause of the apparent exhaustion is, and he should be able to show the farmer what his sources of loss are and be able to suggest a remedy. It has been shown by many experiments that in the ordinary and common methods of farm practice there is a loss of the important element nitrogen from the soil greater than that accounted for by the removal of crops, and, furthermore, that the judicious application of commercial fertilizer or of yard manures does not result in proportionately increasing, or even maintaining the content of nitrogen in such soils. The chemist, with his present knowledge, advises that the loss may be due to either of three causes, or of one or more combined, viz., percolation into the drains, oxidation, or denitrification, but they are unable to suggest a method of practice which will remove the cause of loss. This is a problem of the first importance the solution of which must rest with the chemist.—Abstracted from a paper read before the American Chemical Society.

Andrew Carnegie when asked by a number of financiers whether he thought that the difference between one style of organization and another amounted to much, provided the company had an up-to-date plant properly located, said in effect that should some great catastrophe destroy all of his mills but spare his organization, which had required many years to perfect, he might be inconvenienced temporarily, but that he could depend upon his organization to re-establish his business. If, however, he should lose his organization, even if his mills, which were the best in existence, were left intact, he would not have time nor strength to rehabilitate himself in the business world. Just as we have, for instance, recently seen it demonstrated that opposing armies and navies may have exactly the same guns, but that the side which has behind those guns the men of superior physique, character, intelligence, and skill will win the battle, so also it has been proven that it is not the tool that determines either the quantity or quality of product, but the qualifications for efficiency possessed by the man behind the tool who controls and directs it.

REGENERATION AND TRANSPLANTATION IN ANIMALS.

By Prof. E. KORSCHELT.

REGENERATION and transplantation are intimately connected, for transplantation is regularly followed by regenerative processes. The regeneration of lost parts may take place in adult individuals, long past the period of development. It is a phenomenon common to the entire organic world, although plants are less apt to replace lost parts by a process of true regeneration than by pressing other parts into service and developing adventitious buds. The regeneration of

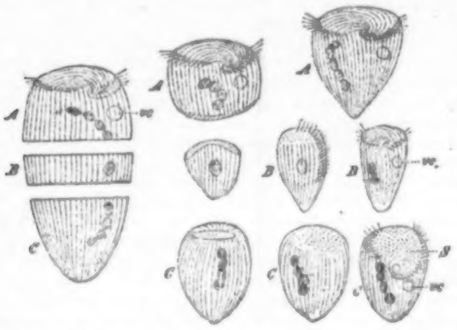


Fig. 1.—Regeneration of a *Stentor* Cut Into Three Pieces.

vc, Pulsating vacuole; *S*, peristom, or mouth region. (After A. Gruber.)

crystals has lately been hinted at, but the broken crystal grows at every point, not only at the surface of fracture.

In the eighteenth century Trembly, Réaumur, Bonnet, Spallanzani, and others proved that the power of regeneration is common to many animals, including fresh water polyps, worms, echinodermata (star fishes, sea urchins, etc.), and the larvæ of amphibia. We now know that it occurs in all classes of animals, from unicellular organisms to vertebrates.

The regeneration of protozoa, the lowest unicellular animals, is of especial importance because it occurs in a simple cell, as it does in plants. If a *Stentor* is cut transversely into two or more pieces each piece develops, according to its original position, a head, a tail, or both (Fig. 1, *A*, *B*, *C*). Regeneration has been observed in a fragment containing only 1/64th of the bulk of the animal. This reconstruction of an entire animal from so small a fragment is analogous to the development of larvæ from small fragments of eggs and the segmentation of the unicellular stage of sea urchins and other animals into 8, 16, or 32 cells.

In the regeneration of protozoa as well as higher animals striking changes of form occur (Fig. 1), but in the former the nucleus is all essential. Fragments of a *Stentor* which contain no part of the nucleus become rounded but die without undergoing true regeneration (Fig. 2). Similar phenomena are observed in plants.

In the cases described above regeneration was induced by mutilation, but protozoa as well as metazoa (multicellular animals) are also capable of "physiological regeneration" caused by purely physiological factors. This includes the creation of reproductive organs, as needed, in protozoa, and the shedding and renewal of skin, hair, feathers, antlers, etc., in metazoa.

A striking power of regeneration after mutilation is exhibited by the fresh water polyp *Hydra*, of which small segments first become rounded, then elongated, and finally develop heads and tails (Fig. 3).

The fresh water worms called *Planaria* possess a still greater power of regeneration, for longitudinal as well as transverse segments develop into complete animals (Fig. 4).

Such regenerative power as this is not common.

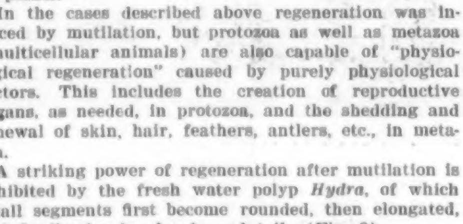


Fig. 2.—A *Stentor* of Which the Amputated Parts Do Not Regenerate Because They Contain None of the Nucleus.

A, *B*, Amputated parts; *K*, nucleus.

Some of the ring worms (*Oligochaetae*) are, however, still more remarkable, for they not only produce, with tolerable certainty, complete individuals from a dozen or more pieces, but they possess the faculty of autotomy or self-division, an external stimulus causing them to break into fragments, which may develop into perfect worms. In this case, regeneration exhibits a certain analogy to the ordinary forms of asexual reproduction.

Even in strongly regenerative animals the faculty is in abeyance in certain parts of the body and in general the power of regeneration diminishes as the organization becomes more complex. Yet it is retained by many articulata, fishes, amphibia, and even reptiles, in such exposed parts as legs, fins, and tails. Hence Weismann regards regeneration as a phenomenon of adaptation to environment, but this view is not universally accepted.

In regeneration occurring in the healing of wounds the origin of the new organs and tissue is of especial interest. The old theory that like is always produced from like and that the process is analogous to embryonal development has been disproved by the discovery of numerous exceptions. These include the formation of the ends of the intestinal canal in the regeneration of Annelida or ring worms, from the inner cotyledon and not, as in embryonal development, from the outer one, the formation of the gill case from the abdominal sack in ascidians (sea-squirts); the formation of the foot from the cup in the feather-star (*Comatula*); and the often-quoted formation of the lens from the iris in the eye of the triton.

In the last and many other cases regeneration from like parts is impossible as all such parts have been removed. Yet the regeneration takes place. The same phenomenon has been observed in embryos in which certian organs developed, although the parts from which those organs are normally produced had been extirpated. When regeneration of this sort occurs in an adult animal it may be due to the persistence of special groups of cells in the embryonal stage or to a retrograde differentiation of all substance. There is much evidence to support the latter assumption.

Barfurth has found that the regenerated part is usually placed normally to the cut surface. As the latter is often oblique to the axis of the body the new part must undergo a subsequent development if it is to remain permanently capable of functional life. In general, processes of growth and transformation play a great part in regeneration. This appears in the development of thin, broad slices of *Hydra* and *Planaria* into long and slender individuals, and still more clearly in Morgan's experiments with *Bipalium*, an elongated terrestrial *Planaria* with a broad head. Fig. 5 illustrates the transformation of a segment, *A*, into a complete individual, *D*.

Here, as in the regeneration of long and thick terminal segments by earth worms (Fig. 6) there must be extensive adaptive changes and, probably, a retrogression or degradation which furnishes the required material. In ascidians, Driesch has observed retrogression carried to the point of complete fusion of the original structure, followed by regeneration from the amorphous mass.

The loss of a part of an organism may be followed, not by regeneration of that part, but by a compensatory regulation or hypertrophy of another part, usually the corresponding part on the opposite side of the body.

In the cases of regeneration which have been described (Figs. 1 to 5) it might almost be taken for granted that the anterior end of the fragment would develop a head and the posterior one a tail. This polarity is still more marked in plants but even in them there are exceptions.

A willow tree planted in an inverted position develops roots from its buried apex and shoots from its unburied base and similar phenomena have been observed in the alga *Bryopsis*.

Jacques Loeb has produced similar reversals of polarity in various hydroid polyps by planting pieces of these plant-like animals in an inverted position, and two-headed monsters by placing the fragments so that both ends were freely exposed to the water (Fig. 7).

Loeb has given the name heteromorphosis to this growth of an organ or member in a part of the body to which it does not belong. He has observed it not only in *Coelenterata* (jelly fishes, corals, sponges, etc.), but also in *Planaria*, which may develop posterior and lateral heads (Fig. 8), and in earth worms in which a tail may be produced at the anterior end of a fragment. Very interesting phenomena of heteromorphosis have been produced by Herbst in crabs, in which a feeler sprouted in the place of an eye that had been removed together with the optic ganglion, but a new eye was developed if only the eye had been removed and the ganglion left undisturbed (Fig. 9).

The occurrence of heteromorphosis proves that in regeneration forms may be produced that cannot perform the normal functions of the lost parts because they are defective or superfluous. The duplication of heads, tails, and limbs is analogous to the duplication of embryonal parts.

The cause of the occurrence and even of the character of regeneration has been sought in the nature of the mutilation. The normal condition of the system is disturbed and resistances of growth are removed

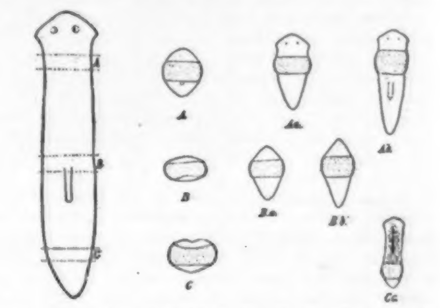


Fig. 4.—*Planaria*, of Which Small Transverse Slices (*A*, *B*, *C*) Develop Into Complete Worms.

so that changes of relative tension acquire importance even in cases where the regeneration does not take place precisely at the wound itself.

In many cases, such as the replacement of the eyes of decapod crustaceans (Fig. 9) the influence of the nervous system is plainly apparent. Other internal factors that affect regeneration are the state of nutrition, age, and chemotactic actions. The external factors include temperature, light, gravity, changes in the surrounding medium, etc.

Transplantation is closely related to regeneration, because it necessarily causes wounds which give rise to regeneration, but independently of this, transplantation is frequently accomplished by extensive regeneration.

Because of its importance in surgery human transplantation has been practised for centuries and transplantations have long been made in the bodies of animals as well. Trembly's experiments on *Hydra* are of especial interest in this connection because of their striking contrast to transplantations in human surgery. In the latter the transplanted portions are very small, but in the lower animals, portions which are large in comparison with the rest of the body, even portions capable of independent existence, can be combined with each other to form permanent, living individuals. This has been done with *Hydra*, worms, pupæ of insects, and larvæ of amphibia.

Such combinations are most easily effected when the parts are taken from the same individual or individuals of the same species. It is very difficult to combine parts taken from different species.

The success and the permanence of the union are favored by the growing together of similar organs, which is so complete in some cases that the combined individual shows no trace of its method of formation. Earth worms built up of two or three pieces have been kept alive ten years and combined amphibia larvæ have survived their metamorphosis into the adult stage.

Small fragments transplanted to other organs are seldom capable of permanent existence in their new environment. Sooner or later they perish from lack of nutriment or other causes. But sometimes they perform their functions after transplantation as in Ribbert's transplantations of the mammary gland of a guinea pig to her ear, and the ovary to the abdominal wall.

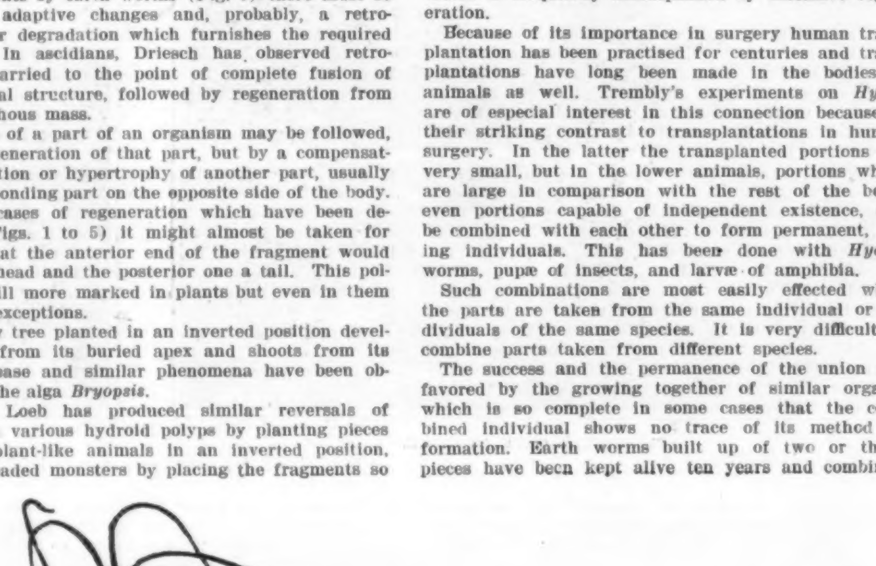


Fig. 3.—*Hydra*. A Transverse Segment (a) Becomes Rounded (a, a^1, a^2), Elongates (a^3) Forms Tubercles (a^4) and Develops Into a New Polyp (a^5, a^6).

Transplantations to other parts of the body are much more successfully accomplished in embryos and larvæ, and the subsequent development and transformation of such transplanted portions have led to most interesting and astonishing results (Born, Harrison, Braus, Spemann, Banchi, Lewis).

The combination of parts taken from different species is of peculiar interest because of the importance of the question whether parts welded together exert any influence on each other. Such combinations, as we have seen, are very difficult to effect, but parts of earth worms and larval amphibia of different species have been brought into long-continued and even permanent union. There is certainly no mutual influence, for even very small parts, which are, so to speak, completely dominated and necessarily nourished by

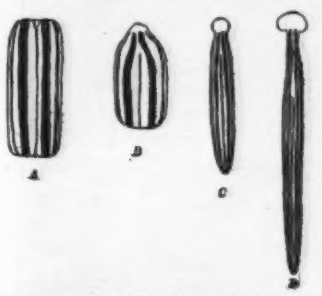


Fig. 5.—Transformation of a Segment (A) of *Bipalium* Through the Forms B and C to the Perfect Animal, D. (After Morgan.)

their far larger partners, always preserve the characters peculiar to their species and transmit them to the parts which they create by regeneration. In like manner fragments transplanted to other parts of the body of the same individual do not change in character, unless they fail to make organic connection with their new environment and are therefore treated as foreign bodies by the organism.

Another interesting question concerns the effect of the orientation of the transplanted part upon the success of the transplantation and union. In *Hydra* it is possible to overcome the normal polarity and effect permanent union of two parts joined by like poles, a result which agrees with the phenomena of heteromorphosis observed in these simple organisms, but Joest and Bornhave proved that earth worms and amphibia larvæ can also be joined by like poles. This proves that polarity is much weaker in animals than in plants, in which inverted grafts never flourish.

From animal combinations connected by like poles a part of one component has been partly amputated with the result that the stump generated a tail in place of an amputated head, or the reverse. If these cases are not simply heteromorphosis they indicate an influence of the larger upon the smaller component in respect to polarity which is inconsistent with the usual preservation of characteristics by transplanted parts. In any event, these observations point to a new and important relation between transplantation and regeneration.—Translated for the SCIENTIFIC AMERICAN from Umschau.

ELECTRICITY IN THE TREATMENT OF DISEASE.*

By JOHN V. SHOEMAKER.

IN order to obtain the best results in practice it is important that we shall bear in mind the limitations of electricity in clinical medicine, because if these are disregarded we may expect to meet with certain disappointment. Extravagant claims made by too enthusiastic advocates are not only unjust to this valuable therapeutic resource, but they are also unjust to the patients who are led to expect impossibilities.

I think it will lead to a clearer view of electricity from the medical standpoint if we lay aside for the moment any preconception we have in our minds with regard to its being a mysterious, life-giving force, capable of working miracles upon the human body, and as being at all times constructive, energizing, and beneficent in its effects in pathological conditions. This, I know, is the popular idea, which has

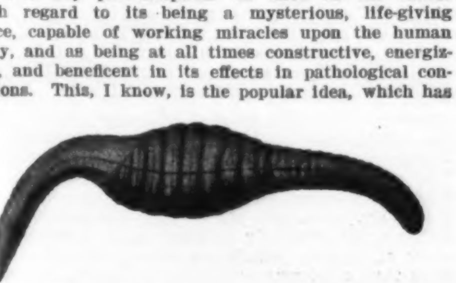


Fig. 6.—**Slice of the Posterior Half of an Earth Worm (*Helodulus longus*) with Regenerated Head and Tail.**

been largely founded upon the seductive and boastful advertisements of charlatans, who have found this a fruitful field in which to work on the credulity of the ignorant public. "There is no sacred disease," said Hippocrates, "or all diseases are equally sacred." So we may say with regard to remedies, there is no mysterious remedy, or all remedies are equally mysterious.

Mercury, arsenic and other potent drugs may, according to circumstances, act as caustic agents and destroy tissues, or they may act as tonics and favor physiological changes. In the same way electricity may be used in medicine to destroy tissue, or, on the other hand, to favorably influence metabolism, depending upon the form in which it is used and the skill with which it is applied.

Let us now briefly consider the forms in which electricity is utilized in medical practice. We ob-

Fig. 7.—Piece of Communal Stem of *Tubularia mesembryanthemum* with New Heads or Polyps Growing at Both Ends. (After Jacques Loeb.)

serve, in the first place, that it is used both indirectly and directly. Among the indirect applications of electricity are those in which it is employed as a source of heat, light, magnetism, and X-rays. As illustrations of the former I may mention the galvanocautery, the electric light and the Roentgen apparatus; also the electromagnet. Illustrations of the direct application are the galvanic, the static, and the induced currents, obtained from the ordinary medical coil or from the large commercial dynamo. The latter, however, is much more powerful than is required for medical purposes, but it may be reduced by transformers and controllers, or "stepped down," so that it can be used therapeutically, as well as for heating and lighting the doctor's office.

The first point that I wish to make is that electricity is always the same in itself, but, like the other agents I have named, it may be given in different dosage and in different ways, so that entirely different therapeutic results may be obtained. Success in therapeutics, whether in the use of electricity or any other remedial agent, depends, as we know, very largely upon the personal skill and good judgment of the physician who makes use of it. This method of regarding the subject will help to explain why certain conditions, such as neuralgia, may be treated successfully either by galvanism, static electricity or by the Roentgen ray; these apparently different forms of electricity being skillfully employed to produce apparently the same local effects.

Taking a broad view of the subject, we observe that electricity is employed in therapeutics to accomplish certain definite ends. These objects may in some cases be attained by several different methods or forms of application. It is also true that others apparently, so far as we know, can only be accomplished by special apparatus and by a single method or technique. In fact, particular means are often employed to obtain definite results, because at present they appear to be the best which have yet been devised to fulfill the special conditions.

With regard to the *modus medendi*, or the physiological action of the agent, we may observe that electricity may be used to produce the following effects:

1. To produce local necrosis, or an eschar. Limited

Fig. 8.—*Planaria* with Heads Sprouting in Various Parts of the Body.

application may not go so far as to cause tissue or cell destruction, and may only produce local vascular changes, or, in other words, they may act as rubefacients or counter-irritants. Powerful currents, if passed through the body, will, on the contrary, abruptly terminate and abolish all physiological processes.

2. To disturb the electrical relations of the elements of nerves and muscles. This is shown by muscular contractions, produced when a nerve trunk and a voluntary muscle are brought within the influence of a current of appropriate strength. It is to be observed here that the electricity primarily gives no additional strength to the nerve or muscle, but simply calls into action energy which is already there. However, by its power to call into play the latent energy of the muscle, it causes movements of the muscle, which in turn leads secondarily to increased blood supply and improvement in nutrition. Illustrations of this are very common, as in treating muscular paralysis.

3. To modify metabolism. Its effects in this direction are well illustrated by the Roentgen apparatus. Exposure to the X-rays causes local nutritive changes in the skin, the linugo hairs fall out from the operator's hands, the skin becomes glossy and thin from the atrophy of the glands, chronic ulceration may occur, which in turn may be followed by malignant disease. It has been repeatedly observed that unguarded exposure of the body to the X-rays causes degenerative and atrophic changes in the deeper parts, especially in the fundus of the eye. In therapeutics this inhibitory and atrophic action may be skillfully directed against cancerous or other new growths. The latter, having less power of resistance than normal tissue are made to undergo retrograde change and to wither away. This is especially noticeable in epithelioma of the skin, and also in accessible organs.

4. To act as a temporary stimulant to nutritive processes, and especially to the nervous system and the circulatory apparatus. This is illustrated by the good effects upon nutrition produced by the static current and electric bath, in anæmia, neurasthenia, atonic dyspepsia, chronic rheumatism, and incipient tuberculosis.

5. To accomplish certain local effects by stimulating physiological functions. This is shown in the use of electricity to increase the flow of milk from the mammary gland. The systematic application to the scalp causes improved nourishment of hair follicles, and not only prevents baldness, but also actually increases the growth and thickness of the hair.

6. To destroy parasites upon the surface of the body. Many infectious diseases of the skin caused by vegetable micro-organisms are promptly cured by the X-rays.

7. To produce electrolysis. By means of needles introduced into the skin and the passage of a suitable galvanic current, decomposition of fluids and solids occurs, and as a result there may be absorption of new growth. This is utilized in treating keloid or

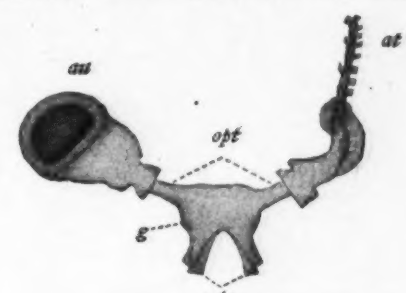


Fig. 9.—Formation of a Feeler Instead of an Eye in *Palemon* (a Decapod Crab).

at, antenna; *au*, eye; *g*, brain; *opt*, optic nerve; *schc*, optic commissure.

hypertrophied tissue of the nose or throat, and in the destruction of pigmented moles, and the removal of superfluous hair.

8. To produce intense light. The method, introduced by Finsen, which has been modified by the use of the electric source of illumination, has yielded really remarkable results from its action upon lupus, and on some superficial malignant growths. The electric light bath has been vaunted as a great restorative agent, but its utility is doubtful. In its operation the entire body is exposed to several hundred incandescent lights. In studying its effects it is difficult to separate the effects of the heat of the bulbs (which acts like a Turkish bath) from the effects of the light itself. We know that light is very irritating to the nervous system, and that the intense sunlight of tropical regions makes these unfit for a permanent residence for white races of men. At all events, the electric light bath does not act like the electric bath, but simply as a light and heat bath.

9. To produce high degree of heat. I need not stop to speak of the uses of the galvanocautery in surgery. It is a complete substitute for the actual cautery, and is superior to it when used as the caustic loop in removing vascular growths on the tonsils; especially in cases of hemophilia.

10. To produce magnetic effects. The electric magnetic coil is used to extract iron fragments from the eye in surgery. It is also utilized in the electric balance for detecting the location of a foreign body, such as a bullet embedded in the tissues.

The use of the X-ray in photography and in diagnosis, as in the skiascope, does not properly come within the province of the therapeutic applications of electricity.

I have now mentioned quite a number of useful applications of electricity in medicine, and I have by no means exhausted the list.

The second practical point I wish to make with regard to electricity, and with which I will close these rather desultory remarks, is this, and I regard it as a most important one:

Electricity, in most cases, is to be regarded as only an adjunct to other treatment. While giving the special electric application we should also give appropriate remedies to act upon the glands of excretion and

* Abstract of a paper read before the Pennsylvania State Medical Society at Bedford Springs, Pa.

secretion. We should consider the state of the blood and give hematonics to increase the blood corpuscles and hemoglobin, or give antidotes to certain toxins, or eliminants to carry off gouty, rheumatic, or other pathogenic agents, in addition to our prescription of electricity. Massage, exercise in the fresh air, a proper diet, regulation of habits of the individual, all these are accessory agents and should be conjoined with the electrical treatment if we wish to obtain the best results. Such, indeed, is the intelligent medical use of this agent in the hands of the qualified physician. Without such therapeutic accessories, electricity, like massage, is very restricted in its usefulness and tends toward charlatanism.

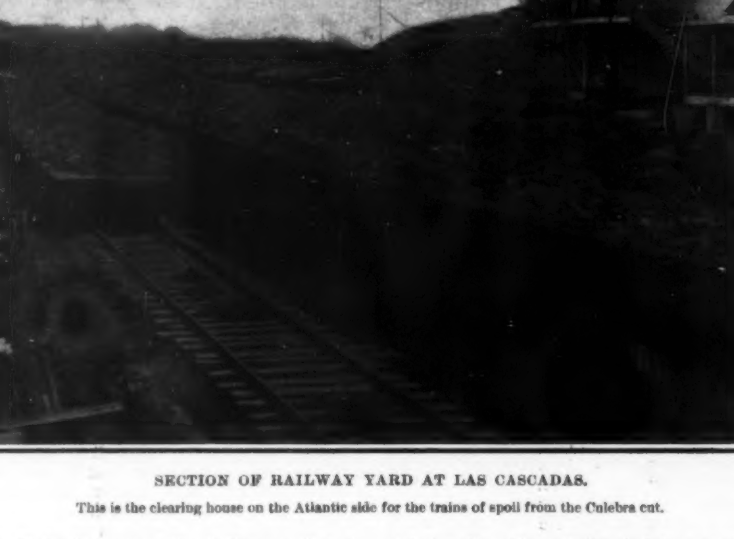
[Concluded from SUPPLEMENT No. 1617, page 25910.]

SPECIAL MESSAGE OF THE PRESIDENT OF THE UNITED STATES CONCERNING THE PANAMA CANAL, COMMUNICATED TO THE TWO HOUSES OF CONGRESS ON DECEMBER 17, 1906.

NEXT in importance to the problem of sanitation, and indeed now of equal importance, is the problem of securing and caring for the mechanics, laborers, and other employees who actually do the work on the canal and the railroad. This great task has been under the control of Mr. Jackson Smith, and on the whole has been well done. At present there are some 6,000 white employees and some 19,000 colored employees on the Isthmus. I went over the different places where the different kinds of employees were working; I think I saw representatives of every type both at their work and in their homes; and I conversed with probably a couple of hundred of them all told, choosing them at random from every class and including those who came especially to present certain grievances. I found that those who did not come specifically to present grievances almost invariably expressed far greater content and satisfaction with the conditions than did those who called to make complaint.

Nearly 5,000 of the white employees had come from the United States. No man can see these young, vigorous men energetically doing their duty without a thrill of pride in them as Americans. They represent on the average a high class. Doubtless to Congress the wages paid them will seem high, but as a matter of fact the only general complaint which I found had any real basis among the complaints made to me upon the Isthmus was that, owing to the peculiar surroundings, the cost of living, and the distance from home, the wages were really not as high as they should be. In fact, almost every man I spoke to felt that he ought to be receiving more money—a view, however, which the average man who stays at home in the United States probably likewise holds as regards himself. Later I shall confer on the subject with certain representative labor men here in the United States, as well as going over with Mr. Stevens, the comparative wages paid on the zone and at home; and I may then communicate my findings to the canal committees of the two Houses.

The white Americans are employed, some of them in office work, but the majority in handling the great steam shovels, as engineers and conductors on the dirt trains, as machinists in the great repair shops, as carpenters and time-keepers, superintendents, and foremen of divisions and of gangs, and so on and so on. Many of them have brought down their wives and families; and the children when not in school are running about and behaving precisely as the American small boy and small girl behave at home. The bachelors among the employees live, sometimes in small separate houses, sometimes in large houses; quarters being furnished free to all the men, married and unmarried. Usually the bachelors sleep two in a room, as they would do in this country. I found a few cases where three were in a room; and I was told of, although I did not see, large rooms in which four were sleeping, for it is not possible in what is really a vast system of construction camps always to provide in advance as ample house room as the Commission intend later to give. In one case, where the house was an old French house with a leak in the roof, I did not think the accommodations were good. But in every other case among the scores of houses I entered at random, the accommodations were good; every room was neat and clean, usually having books, magazines, and small ornaments; and in short just such a room as a self-respecting craftsman would be glad to live in at home. The quarters for the married people were even better. Doubtless there must be here and there a married couple who, with or without reason, are not contented with their house on the Isthmus; but I never happened to strike such a couple. The wives of the steam-shovel men, engineers, machinists, and carpenters into whose houses I went, all with one accord expressed their pleasure in their home life and surroundings. Indeed I do not think they could have done otherwise. The houses themselves were excellent—bathroom, sitting room, piazza, and bedrooms being all that could be desired. In every house which I happened to enter the mistress of the home was evidently a good American housewife and helpmeet, who had given to the home life that touch of attractiveness which, of course, the bachelor quarters neither had nor could have.



SECTION OF RAILWAY YARD AT LAS CASCADAS.

This is the clearing house on the Atlantic side for the trains of spoil from the Culebra cut.

The housewives purchase their supplies directly, or through their husbands, from the commissary stores of the Commission. All to whom I spoke agreed that the supplies were excellent, and all but two stated that there was no complaint to be made; these two complained that the prices were excessive as compared to the prices in the States. On investigation I did not feel that this complaint was well founded. The married men ate at home. The unmarried men sometimes ate at private boarding houses, or private messes, but more often, judging by the answers of those whom I questioned, at the government canteens or hotels where the meal costs 30 cents to each employee. This 30-cent meal struck me as being as good a meal as we get in the United States at the ordinary hotel in which a 50-cent meal is provided. Three-fourths of the men whom I questioned stated that the meals furnished at these government hotels were good, the remaining one-fourth that they were not good. I myself took dinner at the La Boca government hotel, no warning whatever having been given of my coming. There were two rooms, as generally, in these hotels. In one the employees were allowed to dine without their coats, while in the other they had to put them on. The 30-cent meal included soup, native beef (which was good), mashed potatoes, peas, beets, chili con carne, plum pudding, tea, coffee—each man having as much of each dish as he desired. On the table there was a bottle of liquid quinine tonic, which two-thirds of the guests, as I was informed, used every day. There were neat tablecloths and napkins. The men, who were taking the meal at or about the same time, included railroad men, machinists, shipwrights, and members of the office force. The rooms were clean, comfortable, and airy, with mosquito screens around the outer piazza. I was informed by some of those present that this hotel, and also the other similar hotels, were every Saturday night turned into clubhouses where the American officials, the school teachers, and various employees, appeared, bringing their wives, there being dancing and singing. There was a piano in the room, which I was informed was used for the music on these occasions. My meal was excellent, and two newspaper correspondents who had been on the Isthmus several days informed me that it was precisely like the meals they had been getting elsewhere at other government hotels. One of the employees was a cousin of one of the Secret Service men who was with me, and he stated that the meals had always been good, but that after a time he grew tired of them because they seemed so much alike.

I came to the conclusion that, speaking generally, there was no warrant for complaints about the food. Doubtless it grows monotonous after a while. Any man accustomed to handling large masses of men knows that some of them, even though otherwise very good men, are sure to grumble about something, and usually about their food. Schoolboys, college boys, and boarders in boarding houses make similar complaints; so do soldiers and sailors. On this very trip, on one of the warships, a seaman came to complain to the second watch officer about the quality of the cocoa at the seamen's mess, saying that it was not sweet enough; it was pointed out to him that there was sugar on the table and he could always put it in, to which he responded that that was the cook's business and not his! I think that the complaint as to the food on the Isthmus has but little more foundation than that of the sailor in question. Moreover, I was given to understand that one real cause of complaint was that at the government hotels no liquor is served, and some of the drinking men, therefore, refused to go to them. The number of men using the government hotels is steadily increasing.

Of the nineteen or twenty thousand day laborers employed on the canal, a few hundred are Spaniards. These do excellent work. Their foremen told me that they did twice as well as the West India laborers. They keep healthy and no difficulty is experienced with them in any way. Some Italian laborers are also employed in connection with the drilling. As might be expected, with labor as high priced as at present in the United States, it has not so far proved practicable to get any ordinary laborers from the United States. The American wage-workers on the Isthmus are the highly-paid skilled mechanics of the types mentioned previously. A steady effort is being made to secure Italians, and especially to secure more Spaniards, because of the very satisfactory results that have come from their employment; and their numbers will be increased as far as possible. It has not proved possible, however, to get them in anything like the numbers needed for the work, and from present appearances we shall in the main have to rely, for the ordinary unskilled work, partly upon colored laborers from the West Indies, partly upon Chinese labor. It certainly ought to be unnecessary to point out that the American workingman in the United States has no concern whatever in the question as to whether the rough work on the Isthmus, which is performed by aliens in any event, is done by aliens from one country with a black skin or by aliens from another country with a yellow skin. Our business is to dig the canal as efficiently and as quickly as possible; provided always that nothing is done that is inhumane to any laborers, and nothing that interferes with the wages of or lowers the standard of living of our own workmen. Having in

CULEBRA—MARRIED QUARTERS.

THE PRESIDENT'S STORY OF HIS VISIT TO PANAMA.

view this principle, I have arranged to try several thousand Chinese laborers. This is desirable both because we must try to find out what laborers are most efficient, and, furthermore, because we should not leave ourselves at the mercy of any one type of foreign labor. At present the great bulk of the unskilled labor on the Isthmus is done by West India negroes, chiefly from Jamaica, Barbados, and other English possessions. One of the governors of the lands in question has shown an unfriendly disposition to our work, and has thrown obstacles in the way of our getting the labor needed; and it is highly undesirable to give any outsiders the impression, however ill fo nded, that they are indispensable and can dictate terms to us.

RAILWAY YARD AT PEDRO MIGUEL.

This is the clearing house on the Pacific side for trains with spoil from the Culebra cut.

The West India laborers are fairly, but only fairly, satisfactory. Some of the men do very well indeed; the better class, who are to be found as foremen, as skilled mechanics, as policemen, are good men; and many of the ordinary day laborers are also good. But thousands of those who are brought over under contract (at our expense) go off into the jungle to live, or loaf around Colon, or work so badly after the first three or four days as to cause a serious diminution of the amount of labor performed on Friday and Saturday of each week. I questioned many of these Jamaica laborers as to the conditions of their work and what, if any changes, they wished. I received many complaints from them, but as regards most of these complaints they themselves contradicted one another. In all cases where the complaint was as to their treatment by any individual it proved on examination that this individual was himself a West India man of color, either a policeman, a storekeeper, or an assistant storekeeper. Doubtless there must be many complaints against Americans; but those to whom I spoke did not happen to make any such complaint to me. There was no complaint of the housing; I saw but one set of quarters for colored laborers which I thought poor, and this was in an old French house. The barracks for unmarried men are roomy, well ventilated, and clean, with canvas bunks for each man, and a kind of false attic at the top, where the trunks and other belongings of the different men were kept. The clothes are hung on clotheslines, nothing being allowed to be kept on the floor. In each of these big rooms there were tables and lamps, and usually a few books or papers, and in almost every room there was a Bible; the books being the property of the laborers themselves. The cleanliness of the quarters is secured by daily inspection. The quarters for the married negro laborers were good. They were neatly kept, and in almost every case the men living in them, whose wives or daughters did the cooking for them, were far better satisfied and of a higher grade than the ordinary bachelor negroes. Not only were the quarters in which these negro laborers were living much superior to those in which I am informed they live at home, but they were much superior to the huts to be seen in the jungles of Panama itself, beside the railroad tracks, in which the lower class of native Panamans live, as well as the negro workmen when they leave the employ of the canal and go into the jungle. A single glance at the two sets of buildings is enough to show the great superiority in point of comfort, cleanliness, and healthfulness of the government houses as compared with the native houses.

The negroes generally do their own cooking, the bachelors cooking in sheds provided by the government and using their own pots. In the different camps there was a wide variation in the character of these cooking sheds. In some, where the camps were completed, the kitchen or cooking sheds, as well as the bathrooms and water closets, were all in excellent trim, while there were board sidewalks leading from building to building. In other camps the kitchens or cook sheds had not been floored, and the sidewalks had not been put down, while in one camp the bath houses were not yet up. In each case, however, every effort was being made to hurry on the construction, and I do not believe that the delays had been greater than were inevitable in such work. The laborers are accustomed to do their own cooking; but there was much complaint, especially among the bachelors, as to the quantity, and some as to the quality, of the food they got from the commissary department, especially as regards yams. On the other hand, the married men and their wives, and the more advanced among the bachelors, almost invariably expressed themselves as entirely satisfied with their treatment at the commissary stores; except that they stated that they generally could not get yams there, and had to purchase them outside. The chief complaint was that the prices were too high. It is unavoidable that the prices should go higher than in their own homes; and after careful investigation I came to the conclusion that the chief trouble lay in the fact that the yams, plantains, and the like are rather perishable food, and are very bulky compared to the amount of nourishment they contain, so that it is costly to import them in large quantities and difficult to keep them. Nevertheless, I felt that an effort should be made to secure them a more ample supply of their favorite food, and so directed; and I believe that ultimately the government must itself feed them. I am having this matter looked into.

The superintendent having immediate charge of one gang of men at the Colon reservoir stated that he endeavored to get them to substitute beans and other nourishing food for the stringy, watery yams, because the men keep their strength and health better on the more nourishing food. Inasmuch, however, as they are accustomed to yams it is difficult to get them to eat the more strengthening food, and some time elapses before they grow accustomed to it. At this reservoir there has been a curious experience. It is off in the jungle by itself at the end of a couple of miles of a little toy railroad. In order to get the laborers there, they were given free food (and of course free lodgings); and yet it proved difficult to keep them, because they wished to be where they could reach the dramshop and places of amusement.

I was struck by the superior comfort and respectability of the lives of the married men. It would, in my opinion, be a most admirable thing if a much larger number of the men had their wives, for with their advent all complaints about food and cooking are almost sure to cease.

I had an interview with Mr. Mallet, the British consul, to find out if there was any just cause for complaint as to the treatment of the West India negroes. He informed me most emphatically that there was not, and authorized me to give his statement publicity. He said that not only was the condition of the laborers far better than had been the case under the old French company, but that year by year the condition was improving under our own *régime*. He stated that complaints were continually brought to him, and that he always investigated them; and that for the last six months he had failed to find a single complaint of a serious nature that contained any justification whatever.

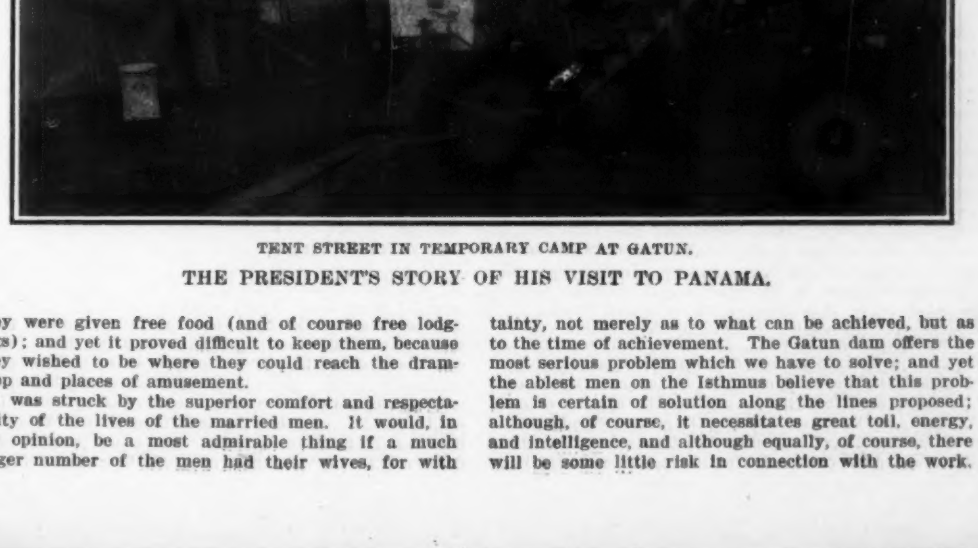
One of the greatest needs at present is to provide amusements both for the white men and the black. The Young Men's Christian Association is trying to do good work and should be in every way encouraged. But the government should do the main work. I have specifically called the attention of the Commission to this matter, and something has been accomplished already. Anything done for the welfare of the men adds to their efficiency and money devoted to that purpose is therefore properly to be considered as spent in building the canal. It is imperatively necessary to provide ample recreation and amusement if the men are to be kept well and healthy. I call the special attention of Congress to this need.

This gathering, distributing, and caring for the great force of laborers is one of the giant features of the work. That friction will from time to time occur in connection therewith is inevitable. The astonishing thing is that the work has been performed so well and that the machinery runs so smoothly. From my own experience I am able to say that more care had been exercised in housing, feeding, and generally paying heed to the needs of the skilled mechanics and ordinary laborers in the work on this canal than is the case in the construction of new railroads or in any other similar private or public work in the United States proper; and it is the testimony of all people competent to speak that on no other similar work anywhere in the tropics—indeed, as far as I know, anywhere else—has there been such forethought and such success achieved in providing for the needs of the men who do the work.

I have now dealt with the hygienic conditions which make it possible to employ a great force of laborers, and with the task of gathering, housing, and feeding these laborers. There remains to consider the actual work which has to be done; the work because of which these laborers are gathered together—the work of constructing the canal. This is under the direct control of the Chief Engineer, Mr. Stevens, who has already shown admirable results, and whom we can safely trust to achieve similar results in the future.

Our people found on the Isthmus a certain amount of old French material and equipment which could be used. Some of it, in addition, could be sold as scrap iron. Some could be used for furnishing the foundation for filling in. For much no possible use could be devised that would not cost more than it would bring in.

The work is now going on with a vigor and efficiency pleasant to witness. The three big problems of the canal are the La Boca dams, the Gatun dam, and the Culebra cut. The Culebra cut must be made, anyhow; but of course changes as to the dams, or at least as to the locks adjacent to the dams, may still occur. The La Boca dams offer no particular problem, the bottom material being so good that there is a practical certainty, not merely as to what can be achieved, but as to the time of achievement. The Gatun dam offers the most serious problem which we have to solve; and yet the ablest men on the Isthmus believe that this problem is certain of solution along the lines proposed; although, of course, it necessitates great toil, energy, and intelligence, and although equally, of course, there will be some little risk in connection with the work.



TENT STREET IN TEMPORARY CAMP AT GATUN.

THE PRESIDENT'S STORY OF HIS VISIT TO PANAMA.

The risk arises from the fact that some of the material near the bottom is not so good as could be desired. If the huge earth dam now contemplated is thrown across from one foothill to the other we will have what is practically a low, broad, mountain ridge behind which will rise the inland lake. This artificial mountain will probably show less seepage, that is, will have greater restraining capacity, than the average natural mountain range. The exact locality of the locks at this dam—as at the other dams—is now being determined. In April next Secretary Taft, with three of the ablest engineers of the country—Messrs. Noble, Stearns, and Ripley—will visit the Isthmus, and the three engineers will make the final and conclusive examinations as to the exact site for each lock. Meanwhile the work is going ahead without a break.

The Culebra cut does not offer such great risks; that is, the damage liable to occur from occasional land slips will not represent what may be called major disasters. The work will merely call for intelligence, perseverance, and executive capacity. It is, however, the work upon which most labor will have to be spent. The dams will be composed of the earth taken out of the cut and very possibly the building of the locks and dams will take even longer than the cutting in Culebra itself.

The main work is now being done in the Culebra cut. It was striking and impressive to see the huge steam shovels in full play, the dumping trains carrying away the rock and earth they dislodged. The implements of French excavating machinery, which often stand a little way back from the line of work, though of excellent construction, look like the veriest toys when compared with these new steam shovels, just as the French dumping cars seem like toy cars when compared with the long trains of huge cars, dumped by steam plows, which are now in use. This represents the enormous advance that has been made in machinery during the past quarter of a century. No doubt a quarter of a century hence this new machinery, of which we are now so proud, will similarly seem out of date, but it is certainly serving its purpose well now. The old French cars had to be entirely discarded. We still have in use a few of the more modern, but not most modern, cars, which hold but twelve yards of earth. They can be employed on certain lines with sharp curves. But the recent cars hold from twenty-five to thirty yards apiece, and instead of the old clumsy methods of unloading them, a steam plow is drawn from end to end of the whole vestibuled train, thus immensely economizing labor. In the rainy season the steam shovels can do but little in dirt, but they work steadily in rock and in the harder ground. There were some twenty-five at work during the time I was on the Isthmus, and their tremendous power and efficiency were most impressive.

As soon as the type of canal was decided this work began in good earnest. The rainy season will shortly be over and then there will be an immense increase in the amount taken out; but even during the last three months, in the rainy season, steady progress is shown by the figures: In August 242,000 cubic yards; in September, 291,000 cubic yards, and in October, 325,000 cubic yards. In October new records were established for the output of individual shovels as well as for the tonnage haul of individual locomotives. I hope to see the growth of a healthy spirit of emulation between the different shovel and locomotive crews, just such a spirit as has grown on our battleships between the different gun crews in matters of marksmanship. Passing through the cut the amount of new work can be seen at a glance. In one place the entire side of a hill had been taken out recently by twenty-seven tons of dynamite, which were exploded at one blast. At another place I was given a Presidential salute of twenty-one charges of dynamite. On the top notch of the Culebra cut the prism is now as wide as it will be; all told, the canal bed at this point has now been sunk down about 200 feet below what it originally was. It will have to be sunk about 130 feet farther. Throughout the cut the drilling, blasting, shoveling, and hauling are going on with constantly increasing energy, the huge shovels being pressed up, as if they were mountain howitzers, into the most unlikely looking places, where they eat their way into the hillsides.

The most advanced methods, not only in construction, but in railroad management, have been applied in the Zone, with corresponding economies in time and cost. This has been shown in the handling of the tonnage from ships into cars, and from cars into ships on the Panama Railroad, where, thanks largely to the efficiency of General Manager Bierd, the saving in time and cost has been noteworthy. My examination tended to show that some of the departments had (doubtless necessarily) become overdeveloped, and could now be reduced or subordinated without impairment of efficiency and with a saving of cost. The chairman of the Commission, Mr. Shonts, has all matters of this kind constantly in view, and is now reorganizing the government of the Zone, so as to make the form of administration both more flexible and less expensive, subordinating everything else to direct efficiency with a view to the work of the Canal Commission. From time to time changes of this kind will undoubtedly have to be made, for it must be remembered that in this giant work of construction, it is continually necessary to develop departments or bureaus, which are vital for the time being, but which soon become useless; just as it will be continually necessary to put up buildings, and even to erect towns, which in ten years will once more give place to jungle, or will then be at the bottom of the great lakes at the ends of the canal.

It is not only natural, but inevitable, that a work as gigantic as this which has been undertaken on the Isthmus should arouse every species of hostility and criticism. The conditions are so new and so trying, and the work so vast, that it would be absolutely out of the question that mistakes should not be made. Checks will occur. Unforeseen difficulties will arise. From time to time seemingly well-settled plans will have to be changed. At present 25,000 men are engaged on the task. After a while the number will be doubled. In such a multitude it is inevitable that there should be here and there a scoundrel. Very many of the poorer class of laborers lack the mental development to protect themselves against either the rascality of others or their own folly, and it is not possible for human wisdom to devise a plan by which they can invariably be protected. In a place which has been for ages a byword for unhealthfulness, and with so large a congregation of strangers suddenly put down and set to hard work there will now and then be outbreaks of disease. There will now and then be shortcomings in administration; there will be unlooked-for accidents to delay the excavation of the cut or the building of the dams and locks. Each such incident will be entirely natural, and, even though serious, no one of them will mean more than a little extra delay or trouble. Yet each, when discovered by sensation mongers and retailed to timid folk of little faith, will serve as an excuse for the belief that the whole work is being badly managed. Experiments will continually be tried in housing, in hygiene, in street repairing, in dredging, and in digging earth and rock. Now and then an experiment will be a failure; and among those who hear of it, a certain proportion of doubting Thomases will at once believe that the whole work is a failure. Doubtless here and there some minor rascality will be uncovered; but as to this, I have to say that after the most painstaking inquiry I have been unable to find a single reputable person who had so much as heard of any serious accusations affecting the honesty of the Commission or of any responsible officer under it. It is not too much to say that the whole atmosphere of the Commission breathes honesty as it breathes efficiency and energy. Above all, the work has been kept absolutely clear of politics. I have never heard even a suggestion of spoils politics in connection with it.

I have investigated every complaint brought to me for which there seemed to be any shadow of foundation. In two or three cases, all of which I have indicated in the course of this message, I came to the conclusion that there was foundation for the complaint, and that the methods of the Commission in the respect complained of could be bettered. In the other instances the complaints proved absolutely baseless, save in two or three instances where they referred to mistakes which the Commission had already itself found out and corrected.

So much for honest criticism. There remains an immense amount of as reckless slander as has ever been published. Where the slanderers are of foreign origin I have no concern with them. Where they are Americans, I feel for them the heartiest contempt and indignation; because, in a spirit of wanton dishonesty and malice, they are trying to interfere with, and hamper the execution of, the greatest work of the kind ever attempted, and are seeking to bring to naught the efforts of their countrymen to put to the credit of America one of the giant feats of the ages. The outrageous accusations of these slanderers constitute a gross libel upon that body of public servants who, for trained intelligence, expert ability, high character, and devotion to duty, have never been excelled anywhere. There is not a man among those directing the work on the Isthmus who has obtained his position on any other basis than merit alone, and not one who has used his position in any way for his own personal or pecuniary advantage.

After most careful consideration we have decided to let out most of the work by contract, if we can come to satisfactory terms with the contractors. The whole work is of a kind suited to the peculiar genius of our people; and our people have developed the type of contractor best fitted to grapple with it. It is of course much better to do the work in large part by contract than to do it all by the government, provided it is possible on the one hand to secure to the contractor a sufficient remuneration to make it worth while for responsible contractors of the best kind to undertake the work; and provided on the other hand it can be done on terms which will not give an excessive profit to the contractor at the expense of the government. After much consideration the plan already promulgated by the Secretary of War was adopted. This plan in its essential features was drafted, after careful and thorough study and consideration, by the Chief Engineer, Mr. Stevens, who, while in the employment of Mr. Hill, the president of the Great Northern Railroad, had personal experience of this very type of contract. Mr. Stevens then submitted the plan to the chairman of the Commission, Mr. Shonts, who went carefully over it with Mr. Rogers, the legal advisor of the Commission, to see that all legal difficulties were met. He then submitted copies of the plan to both Secretary Taft and myself. Secretary Taft submitted it to some of the best counsel at the New York bar, and afterward I went over it very carefully with Mr. Taft and Mr. Shonts, and we laid the plan in its general features before Mr. Root. My conclusion is that it combines the maximum of advantage with the minimum of disadvantage. Under it a premium will be put upon the speedy and economical construction of the canal, and a penalty imposed on delay and waste. The plan as promulgated is tentative; doubtless it will have to be changed in some respects before we can come to a satisfactory agreement with responsible contractors—perhaps even after the bids have been received; and of course it is possible that we cannot come to an agreement, in which case the government will do the work itself. Meanwhile the work on the Isthmus is progressing steadily and without any let-up.

A seven-headed commission is of course a clumsy executive instrument. We should have but one commissioner, with such heads of departments and other officers under him as we may find necessary. We should be expressly permitted to employ the best engineers in the country as consulting engineers.

I accompany this paper with a map showing substantially what the canal will be like when it is finished. When the Culebra cut has been made and the dams built (if they are built as at present proposed) there will then be at both the Pacific and Atlantic ends of the canal, two great fresh-water lakes, connected by a broad channel running at the bottom of a ravine, across the backbone of the Western Hemisphere. Those best informed believe that the work will be completed in about eight years; but it is never safe to prophesy about such a work as this, especially in the tropics.

I am informed that representatives of the commercial clubs of four cities—Boston, Chicago, Cincinnati, and St. Louis—the membership of which includes most of the leading business men of those cities, expect to visit the Isthmus for the purpose of examining the work of construction of the canal. I am glad to hear it, and I shall direct that every facility be given them to see all that is to be seen in the work which the government is doing. Such interest as a visit like this would indicate will have a good effect upon the men who are doing the work, on the one hand, while on the other hand it will offer as witnesses of the exact conditions men whose experience as business men and whose impartiality will make the result of their observations of value to the country as a whole.

Of the success of the enterprise I am as well convinced as one can be of any enterprise that is human. It is a stupendous work upon which our fellow-countrymen are engaged down there on the Isthmus, and while we should hold them to a strict accountability for the way in which they perform it, we should yet recognize, with frank generosity, the epic nature of the task on which they are engaged and its world-wide importance. They are doing something which will redound immeasurably to the credit of America, which will benefit all the world, and which will last for ages to come. Under Mr. Shonts and Mr. Stevens and Dr. Gorgas this work has started with every omen of good fortune. They and their worthy associates, from the highest to the lowest, are entitled to the same credit that we would give to the picked men of a victorious army; for this conquest of peace will, in its great and far-reaching effect, stand as among the very greatest conquests, whether of peace or of war, which have ever been won by any of the peoples of mankind. A badge is to be given to every American citizen who for a specified time has taken part in this work; for participation in it will hereafter be held to reflect honor upon the man participating just as it reflects honor upon a soldier to have belonged to a mighty army in a great war for righteousness. Our fellow-countrymen on the Isthmus are working for our interest and for the national renown in the same spirit and with the same efficiency that the men of the army and navy work in time of war. It behooves us in our turn to do all we can to hold up their hands and to aid them in every way to bring their great work to a triumphant conclusion. Theodore Roosevelt.

The White House, December 17, 1906.

THE HEATING OF FEED WATER TO APPROXIMATELY STEAM TEMPERATURE.

In commenting on thermal storage at the discussion of Messrs. Booth and Kershaw's paper on "Fuel Economy in Steam-Power Plants," read before the Institution of Electrical Engineers in 1905, Col. Crompton said:

"The next point I want to touch upon is that great puzzle to us all, thermal storage. I only wish to say, as a user of thermal storage, that it has come to stay. It is going to be one of the greatest advantages that electrical engineers who have a peak load have introduced into their stations. Not only does it greatly reduce the quantity of boiler plant required, but it also produces economy of a kind which is altogether inexplicable at the present time. It is probably due to causes which have hitherto escaped the attention of physicists. In my discussion with Mr. Halpin as to the remarkable increase of boiler output which we undoubtedly obtain from the use of thermal storage, we have not yet been able to say with any certainty how it is that when we add storage reservoirs to a boiler, and draw from them at the time of heavy load, the increase in boiler output is not confined to the 25 per cent that we would be led to expect by calculation, but we get sometimes an output of at least 150 per cent for two hours in excess of the maximum output which we obtain from the same boilers if the feed-water enters the boiler direct from the economizer at about 250 deg. F. I can not, therefore, pretend to tell you the cause of this remarkable phenomenon, but there is no doubt it exists. Many tests have been made, the measurements repeated so many times, that there can be no possible doubt that thermal storage is a proved fact, and is certain to be a great benefit to power station engineers where a peak load has to be dealt with. I therefore do not agree with the authors that before we use thermal storage we must wait until we have

discovered the cause of the phenomena. It is sufficient to us engineers that we have proved the useful effect, and this ought to be sufficient for us. But, in addition to the increased output the effect of thermal storage in increasing the boiler economy of a station is very remarkable. One power station that I am connected with, which had previously obtained very good boiler economy, has had this increased nearly 25 per cent since thermal storage has been added. The cause of this increase in economy is not so inexplicable as the increase of output, as we can evidently account for part of it by the fact that since we added thermal storage we are able to utilize many of the heat units wasted in the brickwork of our furnaces."

The boilers referred to in the above remarks are the Babcock boilers fitted with thermal storage vessels at the Wood Lane works of the Kensington and Notting Hill Electric Lighting Company, the details of which are as follows:

Each boiler contains 3,654 square feet heating surface, sixty-three square feet of grate area, and carries a thermal storage vessel holding 21,000 gallons of hot feed which we will assume is at the full temperature of the steam, though it is probably considerably less. The steam pressure is 200 pounds per square inch. The normal duty of each boiler is rated at 12,000 pounds per hour, and this normal output can be raised to 30,000 pounds for one hour when using the hot feed, and this is considered an extraordinary performance.

Examining these figures in detail, however, we find nothing extraordinary has been achieved, and results equal to the emergency output should be obtainable without the aid of thermal storage.

At normal output the evaporation averages only 3.28 pounds of steam per hour per square foot of heating surface, or 190 pounds of steam per hour per square foot of grate area. Compared with these results the Harrogate boiler gives at normal duty (viz., consuming twenty-four pounds of fuel per square foot of grate area per hour) an average evaporation of 5.98 pounds of steam per hour per square foot of heating surface or 205 pounds of steam per hour per square foot of grate area.

Taking now the emergency duty of 30,000 pounds available for one hour only, we find that the hot water in the thermal storage vessel, assuming its temperature to be equal to that of the steam, gives to the boiler in heat units during the hour the equivalent of 6,800 pounds of steam at 200 pounds pressure. This leaves 23,200 pounds of steam for the hour as the work of the boiler, which equals an average evaporation of only 6.34 pounds of steam per square foot of heating surface, or 368 pounds per square foot of grate area per hour, and assuming 6.5 pounds of steam evaporated per pound of coal, the combustion of fuel per hour per square foot of grate area equals 56.7 pounds.

Again, comparing the Harrogate boiler without steam-heated feed-water, we obtain on high duty—after making a deduction due to heat from the economizer—an average evaporation of ten pounds per square foot of heating surface, or 397 pounds per square foot of grate area, and with a consumption of 63.4 pounds of fuel per square foot of grate area per hour. With steam-heated feed-water the Harrogate results would be higher and the already higher figures would thereby be considerably increased.

A disadvantage with the hot-feed system of Mr. Halpin's is that only a certain amount of hot feed is available, and when this supply is exhausted the boilers drop down to their normal steaming power and the process of preparing and storing hot-feed water must commence again. A continuous method of securing steam-temperature feed water is to be preferred to a spasmodic one, especially in works occupied in carrying continuous heavy loads.

Since commencing to write this paper, the author came across a very interesting paper read before the Belfast Mechanical and Engineering Association in 1902 on "Live Steam Feed-Water Heating," by A. W. Hamilton, in which it is shown that exhaust-steam heaters and other feed-water heaters, such as Green's economizers, always save more fuel than can be accounted for by the heat units which they return to the boiler in the feed-water, and Mr. Hamilton quotes several carefully made tests on economizers showing 4 per cent, 4.3 per cent, 5.7 per cent and 4.6 per cent saving respectively over and above the actual theoretical saving. In this paper attention is drawn to the results obtained by the late Sir W. Anderson as far back as 1872 concerning experiments carried out with steam-jacketed pans. He found that the quantity of heat passed through the metal per square foot per degree per hour was 260 units when heating water, but that the number of units was 606 after the water began to evaporate, showing a greatly accelerated passage of heat when evaporating; two and one-half times as much, indeed, as when only heating. In another experiment, while heating the water to the boiling point, the heat transmitted per square foot per degree per hour was 368 units; but after evaporation began the heat transmitted was 660 units. Here the passage of heat for evaporating water was 1.8 times as much as in heating without evaporation.

The late Sir Frederick Bramwell made similar experiments with a jacketed copper pan with steam successively of 5, 10, 15, and 30 pounds pressure, raising the water in temperature from 58° to 212° deg. and evaporating it. In the first experiment he found that the rate of transmission of heat per square foot per degree per hour was 162 units, while the water was being heated up to 200 deg.; while in heating from 200 to 212 deg. the rate advanced to 327 units, and when ebullition commenced the rate increased to 427 units. It is thus proved that the hotter the water in the boiler the greater is the amount of heat which passes through the boiler plate per unit of superficial area, the measure of relative efficiency being the gain in temperature of the water when not steaming and the water evaporated when steaming. The increased heating power when steaming represented a gain of over 160 per cent over the heat transmission to water at a less temperature than 200 deg. and over 30 per cent over the heat transmission to water at a temperature between 200 and 212 deg.

The quantity of the draft of steam from a boiler has also an important effect upon the rate of transmission whatever the kind of feed may be, as it is the act of evaporation which produces a more or less rapid rate, and the lowering of the pressure (or maintenance of a pressure) by draft produces the condition of ebullition.

After explaining in a clear and consistent manner the remarkable gain in economy and output due to heating feed-water with live steam, Mr. Hamilton sets out his conclusions as follows:

1. Live steam heaters do save fuel, and economizers show a greater saving than has been accounted for.

2. Evaporating water absorbs heat more rapidly than water which is being only heated.

3. The rate at which heat passes through a plate depends upon the difference of temperature on the two sides of the plate.

4. Evaporation always cools the surface upon which it takes place.

The live steam feed-water heater advocated by Mr. Hamilton consists of a number of perforated trays inserted in the steam space within the boiler; the feed-water is conveyed up the center stem and drips through the holes from tray to tray until finally it reaches the water level, and during its transit through the steam space it picks up a considerable amount of heat from the steam.

This heater, while it is an undoubted improvement on former types of live-steam heaters of the Berryman type, suffers from the serious disadvantage of having no provision for de-aeration of the feed-water, and all the gases occluded are introduced into the boiler; these gases have a detrimental effect on the boiler plates, and experiment has also proved that they prevent in some curious manner the steam from getting freely at the water during its transit; the gases appear to cling round the drops of water and more or less insulate them from the steam.

This is proved by the fact that if water is de-aerated it will pick up the heat from the steam more freely than it does if the de-aeration cocks are closed, and to get full benefit of the steam heat, effective de-aeration must be first secured. Also Mr. Hamilton's heater does not provide for the removal from the boiler of the sulphates and other salts thrown down during the heating process. The removal of these is of the greatest importance if boilers are to be worked on high duty.

Another and more recent method of increasing the temperature of the feed-water to approximately that of the steam is by means of an ingenious and simple feed-water heater made by Messrs. Dales & Braithwaite, engineers, of London, and the author's experiments with this apparatus in the Harrogate electricity works appear to confirm the theories propounded in the earlier portion of this paper.

Mr. Dales set out to find the amount of the difference in the rate of heat transmission to which reference has been made, through surfaces exposed to the absorbing action of water, (1) before it reaches the boiling point, and (2) after that point has been passed, looking for a minimum commercial difference rather than for any minute effects of scientific interest. In this he provided a good spring balance, on which was placed a small ordinary Bunsen flame gas stove, and over this a suitable water-heating vessel was fixed and equipped with a reliable thermometer. The water vessel was covered to prevent evaporation below boiling point at atmospheric pressure. A definite weight of water (say four pounds) was placed in the vessel and the temperature of the water was raised by the gas stove to 100 deg. F. From this temperature the time of an increase to 200 deg. F. was carefully noted. This signified the transmission of a definite number of units of heat from the Bunsen flame to the water within a definite time. Then the thermometer, vessel cover, etc., having been removed, the weight shown on the balance dial was carefully noted, and the water, after reaching the boiling temperature, was allowed to evaporate during the same period of time as in the former test. The weight of water lost by evaporation in the time again denoted the units of heat absorbed in that period. Careful adjustment of the gas flames was made so that they should produce uniform boiling all over the bottom of the vessel to which the heat was applied, also precautions were taken to secure uniformity in the supply of heat, by retaining a regular gas pressure. The experiments were repeated many times in each of the many different sets of conditions.

Mr. Dales found that the rate of heat transmission to the water after ebullition had commenced was 20 per cent greater per unit of time than the transmission during the time occupied in raising the temperature from 100 deg. to 200 deg. F., and that this difference in the rate of transmission under the two conditions of non-evaporative and evaporative heating was the minimum which he could bring about.

It is well known in a general way that almost all the evaporation in a boiler takes place in the region of the fire-box and in a comparatively small area, as the hottest part of the heating surface fixes the temperature and consequent pressure of the steam (excepting so far as this is influenced by the draft of steam from the boiler) while the pressure fixes the boiling point. It will thus be evident that the pressure prevents evaporation in all parts of the boiler where the temperature is at all under the boiling point due to the pressure; and so long as the feed temperature is under the boiling temperature, the boiling area will be less than the total heating surface. This restriction of boiling area will exist to a greater or less extent dependent on the difference in temperature of the feed-water and the temperature of the steam. If all the water which is in contact with all the heating surface in any boiler could have a temperature which is equal to the boiling temperature, and if such heating surface is exposed to a higher temperature than the boiling temperature, ebullition must take place all over the heating surface, the rate of ebullition being in proportion to the different rates according to the supply of heat on such surfaces, and the maximum efficiency producible, for the supply of heat, will be the result. The extent of the boiling area depends on the temperature of the feed, and to a lesser extent upon the distribution of the heat, assuming a constant draft of steam. Following on this, it is evident that the maximum general rate of transmission of heat through the heating surface can only be attained by full temperature feed, which produces a maximum boiling area, which again has a maximum efficiency.

It follows from the foregoing that in all cases where the feed-water of a boiler is injected at any lower temperature than the steam the actual boiling area will be less than the total heating surface, as the water must be in some parts at a lower temperature than the steam, in spite of the continual absorption of the heat from the flues or furnace, and that the whole question of area of evaporation depends upon the temperature of the feed.

The injection water if of a lower temperature than the steam, and if constantly fed, keeps down the temperature of almost the whole of the water of the boiler below that of the hottest part, a graduation of temperature existing according to the supply of heat to the different parts of the boiler. If the fire be forced, while at the same time the temperature of the water differs in parts of the boiler, the heat will only be absorbed at a relatively increased rate temperature for temperature in the boiling area. The boiling area in such a case would be extended, as also it would be by an increase of the temperature of the feed, but the boiling area could only be equal to the whole of the heating surface if the water could be fed to all parts of the boiler at the full temperature due to the steam pressure. It is assumed that the higher efficiency of evaporative as compared with non-evaporative heating surface has been fully established, and in that case it is therefore clear that any temperature of feed has its corresponding boiling area of heating surface, all of which has a minimum greater efficiency than non-boiling area of at least twenty per cent.

The objective, then, of boiler arrangements and feed is an absolute maximum of boiling area of heating surface.

COLORS FOR BOOK EDGES.

To produce the marbled or other colored ornamental appearance of book edges water colors are employed, which are squirted on, or otherwise applied to a gelatinous foundation consisting of a decoction of Carragheen moss or gum tragacanth, allowed to spread over it, and worked up into the required pattern by means of pointed pieces of wood, combs, etc. The thin layer of color thus produced is then transferred to the level surface of the edges of the stitched book. For preparing these water colors—vermilion, carmine vermilion, chrome red, various lakes, chrome yellow in different shades, chrome orange, ultramarine blue, Paris blue, chrome green in various shades, sepia and Cassel brown, ivory black, etc., are the principal colors employed—only the best and purest materials in the form of the most delicate powder are used. They are first soaked in soft water (filtered rain, boiled, or distilled water) and then triturated with great care. Only sufficient water to form a pulpy mass is taken; the latter is then continuously rubbed down on the grinding stone by the runner (top stone) of serpentine, moving circularly. The pressure must never be so great that the stone can be felt, and drying of the color must also be avoided. After some time, when the color has been spread flat on the stone by the process described, it is again gathered together toward the middle with a spatula, and ground until it has become quite lardy. When the colors are prepared in large quantities, mixing machines may be employed for grinding, but the greatest degree of fineness is produced by the above treatment. Even small quantities of colors require to be triturated for one or two hours on the grinding stone to obtain the necessary fineness. The operation cannot be accelerated by rapid grinding and vigorous pressure; and so long as the movement of the running stone can be recognized by the presence of light stripes originating from the grated body color, the color is not fine enough; not until the stone has left a completely smooth and polished surface has the color been sufficiently ground. As only very finely ground colors can be utilized, and it is impossible to obtain a perfect edge when the grinding has been carelessly performed, careful trituration is of the utmost importance. After grinding, the color is again diluted with water to acquire the fluidity necessary for use, and then mixed with a definite quantity of purified gall. The admixture of the latter causes the color to spread in a thin layer on the substratum, and at the same time forms the binding agent. The

ox gall which has been found to be the most suitable is that filtered in as fresh a condition as possible through coarse cloth and then allowed to run through filter paper, a process which takes up some time, but which is absolutely necessary, since badly filtered gall contains portions of grease which interfere with the work. Sixteen per cent of alcohol (90 per cent) is added to the filtered gall; this facilitates the combination with the body colors, and at the same time preserves the gall.

Instead of gall, Venetian soap is sometimes used. This substance prevents tearing of the veins, which sometimes occurs, and also possesses the property of producing the so-called "hair veins" and perfectly circular drops, while gall causes the formation of the most varied figuring.

Aniline dyes are now frequently employed for painting and sprinkling the book edges; they are dissolved in water when required for painting, in diluted alcohol when required for sprinkling. A red paint is made of 2 parts of fuchsine, 5 parts gum Arabic, 10 parts alcohol, and 100 parts water. The alcohol (90 per cent) is poured over the fuchsine, the solution added to the water, and the gum Arabic dissolved in the liquid. Any of the aniline dyes may be used in place of the fuchsine; those, however, should be selected possessing fastness to light.

THE DE LA VAULX AIRSHIP.

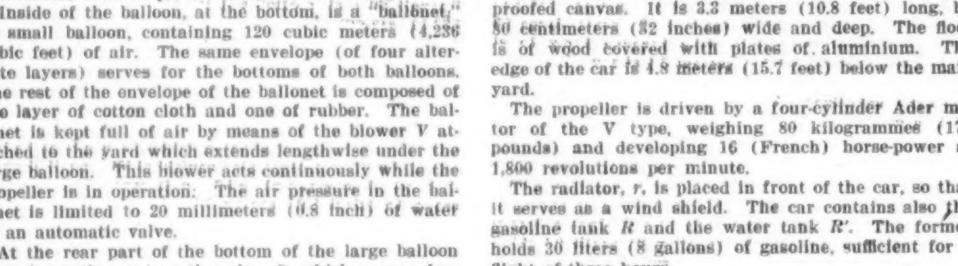
THE airship with which the recent experimental flights of Count de la Vaulx were made is spindle shaped, 32.5 meters (106.6 feet) in length and 6.5 meters (21.3 feet) in its greatest diameter, with a total volume of 720 cubic meters (25,416 cubic feet). The length is five times the diameter, while the length of the "Lebaudy, 1904," is 5.6 times its diameter.

The balloon proper is made of alternate layers of cotton cloth and sheet rubber. There are four layers, the outermost being rubber and the innermost cotton. The outside layer of rubber is protected from the destructive effect of light by a coating of chromate of lead. The tensile strength of the compound fabric is 1,800 kilogrammes per meter (1,200 pounds per foot) in the direction of the warp and 1,200 kilogrammes per meter (800 pounds per foot) perpendicular to the warp. The pieces are joined both by seams and by glue, the seams following meridians and parallel circles perpendicular to the meridians. The junctions are covered, outside and inside, with strips of cloth attached with glue.

Inside of the balloon, at the bottom, is a "ballonet," or small balloon, containing 120 cubic meters (4,236 cubic feet) of air. The same envelope (of four alternate layers) serves for the bottoms of both balloons. The rest of the envelope of the ballonet is composed of one layer of cotton cloth and one of rubber. The ballonet is kept full of air by means of the blower V attached to the yard which extends lengthwise under the large balloon. This blower acts continuously while the propeller is in operation. The air pressure in the ballonet is limited to 20 millimeters (0.8 inch) of water by an automatic valve.

At the rear part of the bottom of the large balloon there is another automatic valve, S, which opens when the pressure of the gas amounts to 35 millimeters (1.4 inch) of water and can also be opened by pulling a cord. The gas bag is provided with a flap and a ripcord for use in emergencies.

The total area of the envelope is about 500 square



COUNT DE LA VAULX'S AIRSHIP, SEEN FROM THE BOW.

meters (5,400 square feet) and its weight, including the ballonet and the valves, is 230 kilogrammes (506 pounds).

The system of suspension presents some very interesting peculiarities. Along each side of the balloon for nearly its entire length extends a longitudinal strip of cloth, sewn fast to the gas bag, a little below the level of its axis. Through holes, made like buttonholes, in each strip of cloth pass short wooden rods attached to a narrow hempen netting P'. Suspenders of steel wire cable are bent and spliced around wooden thimbles attached to the lower edge of the netting and the lower ends of the cables are made fast to the horizontal yard P, which they thus support. These suspenders are reinforced by diagonal cables. The yard P is 22 meters (72 feet) long and 10 centimeters (4 inches) in diameter, and is suspended 2.5 meters (8 feet) below the bottom of the balloon. The yard is a hollow cylinder composed of strips of spruce bound

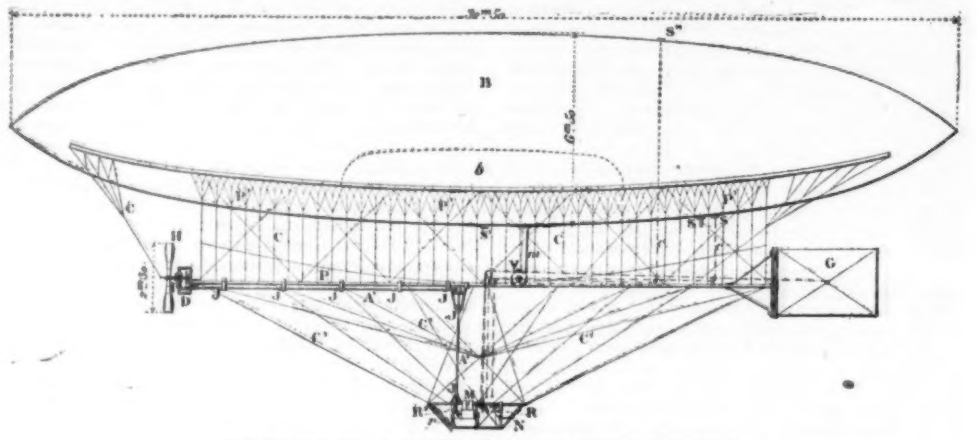


DIAGRAM OF COUNT DE LA VAULX'S AIRSHIP.

B, Hydrogen balloon; b, ballonet containing air; P′ P′ P′, hempen nettings; C C C, steel suspenders; H, propeller; P, main yard; V, blower; A A′, shaft sections; J J J, universal joints; G, rudder; C′ C′ C′, lower suspension system; N, car; M, motor; R, gasoline tank; R′, water tank; r, radiator; S S′ S″ S‴, valves; V′, steering wheel.

together with steel wire and wrapped spirally with silk, which is attached with glue. Distributed along the yard are aluminium collars connected by steel wire shrouds.

In front of this longitudinal yard a transverse yard 2 meters (6.6 feet) long is suspended from the balloon in a similar manner. It serves to relieve the main yard of the reaction of the propeller.

The car, which is suspended from the main yard by a system of steel cables, C', is shaped like a boat and constructed of aluminium tubes covered with fireproofed canvas. It is 3.3 meters (10.8 feet) long, by 80 centimeters (32 inches) wide and deep. The floor is of wood covered with plates of aluminium. The edge of the car is 4.8 meters (15.7 feet) below the main yard.

The propeller is driven by a four-cylinder Ader motor of the V type, weighing 80 kilogrammes (176 pounds) and developing 16 (French) horse-power at 1,800 revolutions per minute.

The radiator, r, is placed in front of the car, so that it serves as a wind shield. The car contains also the gasoline tank R and the water tank R'. The former holds 30 liters (8 gallons) of gasoline, sufficient for a flight of three hours.

The pilot is stationed between the gasoline tank and the motor, with the steering and brake wheels and sparking lever within reach of his hand.

The propeller has only two blades. Its diameter is 2.3 meters (7.6 feet), its pitch 1.1 meter (43 inches). It is a light frame of wood and metal covered with silk, placed at the forward end of the mainyard with its shaft 2 meters (6.6 feet) below the bottom of the balloon, and makes, normally, 900 revolutions a minute. Power is transmitted from the motor to the propeller by a vertical and a horizontal shaft connected by bevel gears. Each shaft is composed of several sections connected by Cardan or universal joints. The horizontal shaft revolves in ball bearings attached to the main yard and its motion is transmitted to the propeller shaft by reducing gears. The vertical shaft can be lengthened or shortened by telescoping.

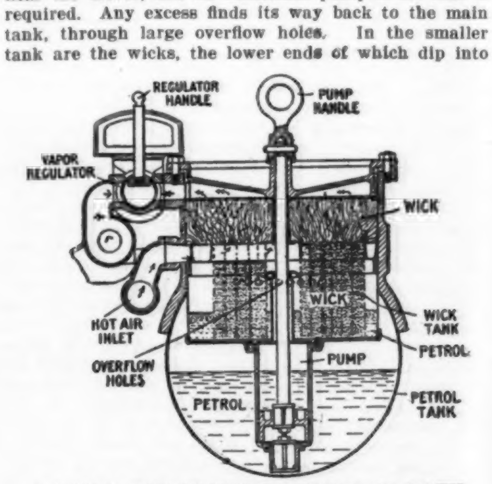
At the rear end of the main yard is the rudder G, formed of a rectangular metal frame, covered with silk. It is 2.9 meters (9.5 feet) long, 1.9 meters (6.2 feet) wide, and 5.5 square meters (59 square feet) in superficial area. It is connected with the steering lever by metal cables.

The airship can carry 100 kilogrammes (220 pounds) in addition to Count de la Vaulx, who weighs nearly as much more. It is so constructed that it can be quickly taken apart and formed into four packages of convenient size for transportation. These packages are: 1, the envelope of the balloon, which makes a bundle of about 1 cubic meter (35 cubic feet); 2, the car, measuring 2 meters by 1 meter (6.6 feet by 3.3 feet); 3 and 4, the two sections of the main yard. The airship was constructed by the engineer-aeronaut Maurice Mallet.

Its first flight was cut short by a failure of the machinery. Its second flight, in the latter part of July, 1906, was a brilliant success. The airship remained aloft eight hours and executed many difficult maneuvers under perfect control.

A WICK CARBURETER.

THE Lanchester car is more often spoken of as the "unconventional" car, and perhaps there is no other car that contains as many exclusive and original characteristics. It may not be common knowledge that this car still adheres to the wick type of carbureter, as originally fitted, and, furthermore, this carbureter has undergone scarcely any change. That it is economical has been amply proved over and over again. We give here a sectional view of this interesting and very simple "lung" of the Lanchester car. The main supply of petrol is contained in a globular tank. At the top of this tank is a smaller chamber, with a capacity of about a gallon of spirit. The spirit is pumped into this smaller tank by a hand pump, a few strokes being sufficient to refill it. The pump handle is placed near the driver, and an occasional pump is all that is required. Any excess finds its way back to the main tank, through large overflow holes. In the smaller tank are the wicks, the lower ends of which dip into



A WICK CARBURETER WHICH IS BOTH EFFICIENT AND SIMPLE.

the petrol, which latter naturally rises up by capillary attraction, and saturates the whole of the top portion of the wick, from which the vapor is drawn on the suction stroke of the engine.

To assist volatilization warm air is drawn through the wick chamber, the hot air inlet being clearly shown. Cold air is drawn through another port, shown by the broad arrow. The vapor regulator is shown, and also the handle for its adjustment. The carbureter is simplicity itself, and has no fine jet or any parts that can get clogged up. It is claimed that even a certain amount of water will not affect it, as the wick will not absorb water, so that this insidious liquid remains below in the main tank.—Motoring Illustrated.

AN EASILY-MADE HIGH-FREQUENCY APPARATUS.*

By A. Frederick Collins.

A general impression seems to prevail among those who have not taken the trouble to scratch the surface of the subject that currents of high frequency and high potential can only be obtained with apparatus of large and special construction, an impression probably resulting from the spectacular experiments performed by Tesla a dozen years ago when the art was yet young.

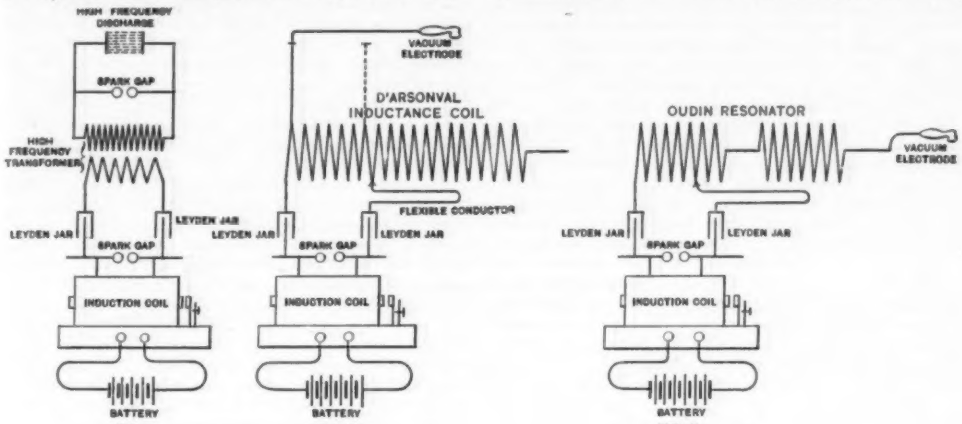


FIG. 1 TESLA HIGH FREQUENCY APPARATUS
FIG. 2 D'ARSONVAL HIGH FREQUENCY APPARATUS
FIG. 3 OUDIN HIGH FREQUENCY APPARATUS

ARRANGEMENT OF HIGH-FREQUENCY APPARATUS.

As a matter of fact, high-frequency and high-potential phenomena are present in the discharge of the smallest induction coil, and a coil giving a spark of two inches will suffice to produce very interesting results, while coils from this size up to the largest made will exhibit all the striking effects in electrical resonance and the action of inductance and capacity of a circuit on oscillating currents with the exception of long disruptive discharges.

At the outset it should be understood that there is only one fundamental method known by which it is possible to set up high-frequency currents, namely, by the equalization of high potentials through the medium of the discharge spark, but there are, however, several forms of devices by which such currents can be manifested and utilized.

The best known of these is the Tesla transformer, formed of a few turns of heavy wire whose ends lead to the outside coatings of a pair of Leyden jars, the inside coatings being connected with the opposite arms of a spark gap which in turn are joined to the terminals of the secondary of an induction coil. Around the primary of the transformer, but exceedingly well insulated from it, is wound the secondary coil, consisting of a single layer of much finer wire whose terminals are connected, as illustrated in the diagram Fig. 1, to a second spark gap. Thus the potential of the current is not only stepped up, but the frequency is enormously increased as well.

An apparatus devised by D'Arsonval for the production of high-frequency currents is much simpler in construction, though it is not as efficient as the Tesla transformer, but it has the advantage of being more easily constructed, while by merely changing a connection it can be converted into an Oudin resonator. These arrangements are called resonators from their analogous action to acoustic resonators which directly reinforces a simple sound vibration, as may be demonstrated by whistling at a low pitch across the open mouth of a bottle and then raising the pitch until a corresponding frequency of vibration equal to that of the natural period of the bottle is reached, when the latter will emit a similar sound and reinforce the note in strength and quality.

D'Arsonval's resonator consists of a simple coil of bare wire wound on a cylinder of some insulating material. One terminal of the coil is connected with the inner coating of one of the Leyden jars, the outer coating of the jar being attached to one of the terminals of the secondary of the induction coil. The opposite terminal of the secondary coil leads to the outer coating of the other jar, while the inner coating is connected with a flexible terminal the end of which carries a spring clip or other means of contact. This clip or contact can be attached to any portion of any of the turns of the resonator, and by varying its position a value of inductance can be found where it cancels the value of capacity, when the effects of the oscillating currents in it will be a maximum. Fig. 2 shows the D'Arsonval resonator diagrammatically.

When this resonator is in action the induction coil charges the two oppositely-disposed Leyden jars which discharge across the spark gap, the balls of which should be only slightly separated to lessen the resistance to a minimum. When the spark takes place the energy stored up in the jars is released and becomes electric currents which oscillate through the circuit of which the resonator coil is a part.

From the above diagrams it is apparent that the Tesla apparatus is bi-polar; that is, there are two terminals which may be used. In D'Arsonval's resonator either one or two poles may be employed, the second pole or terminals being indicated by the dotted line. Oudin's resonator is similar to that of D'Arsonval, but instead of tapping the coil at the points indicated in Fig. 2 he used the single terminal at the end of the supplementary induction coil as shown in Fig. 3, and obtained an accentuated discharge.

This result is due to the fact that the oscillations are not confined to the turns of wire that are included in the closed circuit, but surge with equal intensity in the other and outer turns of the coil which is a continuation of it. These currents produce a high potential in virtue of their exalting action on each other due to the inductance of the circuit.

The high-frequency apparatus shown in Fig. 4 can be used to obtain either D'Arsonval or Oudin currents. The apparatus comprises a plunge battery of six cells, an induction coil giving a two-inch spark, a pair of one-pint Leyden jars, and the inductance coil. The jars may be made by coating the inside and outside surfaces of two preserve or other bottles having wide necks with tin-foil to within one-third of the top; this may be done by shellacking them and then laying on the foil before it is dry, while the exposed parts are given two or three coats of varnish. A thin hardwood stopper, also shellacked and supporting a brass rod fitted with a ball at its upper end and two or three inches of brass chain on its lower end to make contact with the inner foil, is provided for each jar.

The inductance coil can be made by winding twenty turns of bare copper or brass wire, No. 16 or 18, spirally around a tall bottle of uniform diameter. These turns may be spaced approximately one-fourth of an inch apart; the exact distance is not material, though the nearer these are together the greater will be the inductance of the circuit, but it is not advisable to wind them closer than three-sixteenths of an inch. In inductance coils to be used in resonators energized with large induction coils, the distance may be as great as one-half inch, the diameter of the turns 12 inches, and the number of turns about forty.

In making a bottle inductor the turns of wire may easily be kept in place and insulated from each other by applying a compound made by melting equal parts of resin and beeswax in a melted state as the wire is wound on the glass surface and holding it until it has cooled. The flexible conductor may be soldered to a small spring clip or to the end of a wire, say No. 14, and the free end flattened and bent up ¼ inch, so that it can be slipped between a turn of the coil and the bottle, a little scheme that will serve admirably for the adjustable connection. The different parts are then ready to be connected up as shown in the diagram Fig. 2 and the one terminal used when a D'Arsonval current is desired, or the other terminal when an Oudin current is required.

With this simple resonator many experiments may be performed, such as lighting a small incandescent lamp attached to the turns of the inductance coil, impedance and resonance phenomena shown, physiological effects, etc. Of the latter, the lighting of a lamp held in the hands so that the oscillating currents must pass through the body first is a striking example and proves conclusively that when the frequency is sufficiently high, i.e., in the neighborhood of a million reversals per second, the electrical energy will pass through the body without sensation of any kind. High-frequency currents are being widely used at the present time as a therapeutic agent in the treatment of various diseases.

* Specially prepared for the Scientific American Supplement.

Fig. 4.—THE HIGH-FREQUENCY APPARATUS IN USE.

THE ART OF CUTTING METALS.*

By Fred W. Taylor, Philadelphia, President American Society Mechanical Engineers.

The experiments described in this paper were undertaken to obtain a part of the information necessary to establish in a machine shop our system of management, the central idea of which is: (A) to give each workman each day in advance a definite task, with detailed written instructions, and an exact time allowance for each element of the work. (B) To pay extraordinarily high wages to those who perform their tasks in the allotted time, and ordinary wages to those who take more than their time allowance. There are three questions which must be answered each day in every machine shop by every machinist who is running a metal cutting machine, such as a lathe, planer, drill press, milling machine, etc., namely:

a. What tool shall I use?
b. What cutting speed shall I use?
c. What feed shall I use?

Our investigations, which were started 26 years ago with the definite purpose of finding the true answers to these questions under all the varying conditions of machine shop practice, have been carried on up to the present time with this as the main object still in view.

ROUGHING WORK EXCLUSIVELY CONSIDERED.

The writer will confine himself almost exclusively to an attempted solution of this problem as it affects "roughing work;" i. e., the preparation of the forgings or casting for the final finishing cut, which is taken only in those cases where great accuracy or high finish is called for. Fine finishing cuts will not be dealt with. Our principal object will be to describe the fundamental laws and principles which will enable us to do "roughing work" in the shortest time, whether the work is rigid or elastic, and whether the machine tools are light and of small driving power, or heavy and rigid with ample driving power. In other words, our problem is to take the work and machines as we find them in a machine shop and by properly changing the countershaft speeds, equipping the shop with tools of the best quality and shapes and then making a slide rule for each machine to enable an intelligent mechanic with the aid of these slide rules to tell each workman how to do each piece of work in the quickest time.

It may seem strange to say that a slide rule enables a good mechanic to double the output of a machine which has been run, for example, for ten years by a first-class machinst having exceptional knowledge of and experience with his machine, and who has been using his best judgment. Yet our observation shows that, on the average, this understates the fact. To make the reason for this more clear it should be understood that the man with the aid of his slide rule is called upon to determine the effect which each of

* Extracts from Part I. of the President's annual address at the New York meeting (December, 1906) of the American Society of Mechanical Engineers.

the 12 elements or variables given below has upon the choice of cutting speed and feed; and it will be evident that the mechanic, expert or mathematician does not live who, without the aid of a slide rule or its equivalent, can hold in his head these 12 variables and measure their joint effect upon the problem. These twelve elements or variables are as follows:

a. The quality of the metal which is to be cut.

b. The diameter of the work.

c. The depth of the cut.

d. The thickness of the shaving.

e. The elasticity of the work and of the tool.

f. The shape or contour of the cutting edge of the tool, together with its clearance and lip angles.

g. The chemical composition of the steel from which the tool is made, and the heat treatment of the tool.

h. Whether a copious stream of water, or other cooling medium, is used on the tool.

j. The duration of the cut—i. e., the time which a tool must last under pressure of the shaving without being reground.

k. The pressure of the chip or shaving upon the tool.

l. The changes of speed and feed possible in the lathe.

m. The pulling and feeding power of the lathe.

Broadly speaking, the problem of studying the effect of each of the above variables upon the cutting speed and of making this study practically useful may be divided into four sections, as follows:

(A) The determination by a series of experiments of the important facts or laws connected with the art of cutting metals.

(B) The finding of mathematical expressions for these laws which are so simple as to be suited to daily use.

(C) The investigation of the limitations and possibilities of metal cutting machines.

(D) The development of an instrument (a slide rule) which embodies, on the one hand, the laws of cutting metals, and on the other the possibilities and limitations of the particular lathe or planer, etc., to which it applies, and which can be used by a machinist without mathematical training to quickly indicate in each case the speed and feed which will do the work quickest and best.

THE EXPERIMENTS BEGUN IN 1880.

In the fall of 1880 the machinists in the small machine shop of the Midvale Steel Company, Philadelphia, most of whom were working on piecework in machining locomotive tires, car axles, and miscellaneous forgings, had combined to do only a certain number of pieces per day on each type of work. The writer, who was the newly appointed foreman of the shop, realized that it was possible for the men to do in all cases much more work per day than they were accomplishing. He found, however, that his efforts to get the men to increase the output were blocked by the fact that his knowledge of just what combination of depth of cut, feed and cutting speed would in each case do the work in the shortest time was much less accurate than that of the machinists who were combined against him. His conviction that the men were not doing half as much as they should do, however, was so strong that he obtained the permission of the management to make a series of experiments to investigate the laws of cutting metals, with a view to obtaining a knowledge at least equal to that of the combined machinists who were under him. He expected that these experiments would last not longer than six months. With the exception of a few comparatively short periods, however, these experiments have continued until the present time, through a term of about twenty-six years.

The writer wishes to call attention to the fact that in these first experiments he was far more fortunate than almost all of the experimenters who have investigated the subject since then, in having at his disposal a comparatively large mass of uniform metal to work upon, and a comparatively large and powerful machine to work with, a 66-inch diameter boring mill and large locomotive tires made of hard tire steel of uniform quality having been used. He was also especially fortunate in having over him as president of the company William Sellers, who, as is well known, was one of the most patient and broad minded experimenters of his day. Mr. Sellers, in spite of the protests which were made against the continuation of this work, allowed the experiments to proceed, even, at first, at a very considerable inconvenience and loss to the shop.

The extent of this inconvenience will be appreciated when it is understood that we were using a 66-inch diameter vertical boring mill, belt driven by the usual cone pulleys, and that in order to regulate the exact cutting speed of the tool it was necessary to slow down the speed of the engine that drove all of the shafting in the shop, a special adjustable engine governor having been bought for this purpose. For over two years the whole shop was inconvenienced in this way, by having the speed of its main line of shafting greatly varied, not only from day to day but from hour to hour. Before the two years had elapsed, however, the writer had obtained such valuable and unexpected results from the experiments as to much more than justify all of the annoyance and expenditure, and soon after that he readily obtained permission to employ a young technical graduate to devote his whole time to the continuation of this work.

ACKNOWLEDGMENTS TO THOSE WHO ASSISTED IN THE WORK.

G. M. Sinclair, a graduate of Stevens Institute of Technology, devoted his entire time to this work from 1884 to 1887, when he left the employ of the company. H. L. Gantt, also a graduate of Stevens Institute, succeeded Mr. Sinclair in July, 1887, and has been interested with us in carrying on these experiments throughout their whole period. In 1898 Maunsel White, of Bethlehem, another graduate of Stevens Institute, joined us and has been actively interested in our work up to this time. Carl G. Barth, a graduate of the Technical School of Horten, Norway, joined us in 1899, and is still actively working on our investigations.

During these years we have consulted so freely together in all matters relating to these experiments that with few exceptions hardly a step has been taken which can be said to have originated with any one man. Therefore, whatever credit or blame may come to this work should be impartially divided among us. In writing this paper, then, no effort will be made to discriminate, as to the results which have been obtained in our investigations, between the work of one man and another.

In addition to the five men who have mainly directed and carried on this work the writer wishes to acknowledge the most loyal and efficient aid and cooperation of many others who have assisted in the actual running of the machines and in recording or tabulating the data. Among these he would particularly mention Dwight V. Merrick, D. C. Fenner, James Kellogg, Sidney Newbold, Joseph Welden, N. W. Wickersham, Edward Kneisley, and Leonard G. Backstrom.

Our experiments were continued in the works of the Midvale Steel Company until 1889, when the writer left its employ. Since then these investigations have been carried on in various shops and at the expense of different companies. Among these we would especially acknowledge our indebtedness to the Cramp's Shipbuilding Company, Wm. Sellers & Co., the Link-Belt Engineering Company, Dodge & Day, and, more than all, to the Bethlehem Steel Company.

In carrying on this work more than ten machines have been fitted up at various times with special driving apparatus and the other needed appliances, all machines used since 1894 having been equipped with electric drives, so as to obtain any desired cutting speed. The thoroughness with which the work has been done may perhaps be better appreciated when it is understood that we have made between 30,000 and 50,000 recorded experiments, and many others of which no record was kept. In studying these laws we have cut up into chips with our experimental tools more than 800,000 pounds of steel and iron. More than 16,000 experiments were recorded in the Bethlehem Steel Company. We estimate that up to date between $150,000 and $200,000 have been spent upon this work, and it is a very great satisfaction to feel that those whose generosity has enabled us to carry on the experiments have received ample return for their money through the increased output and the economy in running their shops which have resulted from our experiments.

SECRETS GUARDED TWENTY-SIX YEARS NOW REVEALED.

Throughout the whole twenty-six years we have succeeded in keeping almost all of these laws secret, and in fact since 1889 this has been our means of obtaining the money needed to carry on the work. We have never sold any information connected with this art for cash, but we have given to one company after another all of the data and conclusions arrived at through our experiments in consideration for the opportunity of still further continuing our work. In one shop after another machines have been fitted up for our use, workmen furnished us to run them, and specially prepared tools, forgings, and castings supplied in exchange for the data which we had obtained to date; and we have the best indication that they received full value for the money spent from the fact that the same company fitted up for us at intervals of several years three sets of apparatus, the additional knowledge obtained each time evidently warranting them in making the added outlay.

During this period all of the companies who were given this information, and all of the men who worked upon the experiments, were bound by promises to the writer not to give any of this information away nor to allow it to be published. Most of these promises were verbal; and in this day, when there is so much talk about dishonesty and graft in connection with some of our corporations and prominent business men, it is a notable fact that through a period of twenty-six years it has not come to our knowledge that any one of the many men or companies connected with this work has broken a promise. The writer has his doubts whether any other country can produce a parallel record of such widespread good faith among its engineers and mechanics.

It seems to us that the time has now come for the engineering fraternity to have the results of our work, in spite of the fact that this will cut off our former means of financing the experiments. However, we are in hopes that the money required to complete this work may be obtained from some other source.

The writer has no doubt that many of the discoveries and conclusions which mark the progress of this work have been and are well known to other engineers, and we do not record them with any certainty that we were the first to discover or formulate them, but merely to indicate some of the landmarks in the development of our own experiments, which to us were new and of value. The following is a record of some of our more important steps:

CHRONOLOGY OF DISCOVERIES.

A. In 1881, the discovery that a round nosed tool could be run under given conditions at a much higher cutting speed and therefore turn out much more work than the old-fashioned diamond pointed tool.

B. In 1881, the demonstration that, broadly speaking, the use of coarse feeds accompanied by their necessarily slow cutting speeds would do more work than fine feeds with their accompanying high speeds.

C. In 1883, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from the steel forging by the tool, would permit an increase in cutting speed, and, therefore, in the amount of work done of from 30 to 40 per cent. In 1884 a new machine shop was built for the Midvale Steel Works, in the construction of which this discovery played a most important part; each machine being set in a wrought iron pan in which was collected the water (supersaturated with carbonate of soda to prevent rusting), which was thrown in a heavy stream upon the tool for the purpose of cooling it. The water from each of these pans was carried through suitable drain pipes beneath the floor to a central well from which it was pumped to an overhead tank from which a system of supply pipes led to each machine. Up to that time the use of water for cooling tools was confined to small cans or tanks from which only a minute stream was allowed to trickle upon the tool and the work, more for the purpose of obtaining a water finish on the work than with the object of cooling the tool; and, in fact, these small streams of water are utterly inadequate for the latter purpose. So far as the writer knows, in spite of the fact that the shops of the Midvale Steel Works until recently have been open to the public since 1884, no other shop in this country was similarly fitted up until that of the Bethlehem Steel Company in 1899, with the one exception of a small steel works which was an offshoot in personnel from the Midvale Steel Company.

D. In 1883, the completion of a set of experiments with round nosed tools; first, with varying thicknesses of feed when the depth of the cut was maintained constant; and, second, with varying depths of cut while the feed remained constant, to determine the effect of these two elements on the cutting speed.

E. In 1883, the demonstration of the fact that the longer a tool is called upon to work continuously under pressure of a shaving, the slower must be the cutting speed, and the exact determination of the effect of the duration of the cut upon the cutting speed.

F. In 1883, the development of formulæ which gave mathematical expression to the two broad laws above referred to. Fortunately these formulæ were of the type capable of logarithmic expression and therefore suited to the gradual mathematical development extending through a long period of years, which resulted in making our slide rules and solved the whole problem in 1901.

G. In 1883, the experimental determination of the pressure upon the tool required on steel tires to remove cuts of varying depths and thickness of shaving.

H. In 1883, the starting of a set of experiments on belting described in a paper published in Transactions, Vol. 15 (1894).

J. In 1883, the measurement of the power required to feed a round nosed tool with varying depths of cut and thickness of shaving when cutting a steel tire. This experiment showed that a very dull tool required as much pressure to feed it as to drive the cut. This was one of the most important discoveries made by us, and as a result all steel cutting machines purchased since that time by the Midvale Steel Company have been supplied with feeding power equal to their driving power, and very greatly in excess of that used on standard machine tools.

K. In 1884, the design of an automatic grinder for grinding tools in lots and the construction of a tool-room for storing and issuing tools ready ground to the men.

L. From 1885 to 1889, the making of a series of practical tables for a number of machines in the shops of the Midvale Steel Company, by the aid of which it was possible to give definite tasks each day to the machinists who were running machines, and which resulted in a great increase in their output.

M. In 1886, the demonstration that the thickness of the chip or layer of metal removed by the tool has a much greater effect upon the cutting speed than any other element, and the practical use of this knowledge in making and putting into everyday use in our shops a series of broad nosed cutting tools which enabled us to run with a coarse feed at as high a speed as has been before attained with round nosed tools when using a fine feed, thus substituting, for a considerable portion of the work, coarse feeds and high speeds for our old maxim of coarse feeds and slow speeds.

N. In 1894 and 1895, the discovery that a greater proportional gain could be made in cutting soft metals through the use of tools made from self-hardening steels than in cutting hard metals, the gain made by the use of self-hardening tools over tempered tools in cutting soft cast iron being almost 90 per cent, whereas the gain in cutting hard steels or hard cast iron was only about 45 per cent. Up to this time the use of Mushet and other self-hardening tools had been almost exclusively confined to cutting hard metals, a few tools made of Mushet steel being kept on hand in every shop for special use on hard castings or forgings which could not be cut by the tempered tools. This experiment resulted in substituting self-hardening tools for tempered tools for all "roughing work" throughout the machine shop.

P. In 1894 and 1895, the discovery that in cutting wrought iron or steel a heavy stream of water thrown upon the shaving at the nose of the tool produced a

gain in cutting speed of self-hardening tools of about 33 per cent. Up to this time the makers of self-hardening steel had warned users never to use water on the tools.

Q. From 1898 to 1900, the discovery and development of the Taylor-White process of treating tools; namely, the discovery that tools made from chromium-tungsten steels when heated to the melting point would do from two to four times as much work as other tools.

R. In 1899-1902, the development of our slide rules, which are so simple that they enable an ordinary workman to make practical and rapid everyday use in the shop of all the laws and formulæ deduced from our experiments.

S. In 1906, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from cast iron by the tool would permit an increase in cutting speed, and therefore in the amount of work done, of 16 per cent.

T. In 1906, the discovery that by adding a small quantity of vanadium to tool steel to be used for making modern high speed chromium-tungsten tools heated to near the melting point, the hardness and endurance of tools, as well as their cutting speeds, are materially improved.

(To be concluded.)

SCIENCE NOTES.

In a series of researches upon the spectra of neon, crypton, and xenon, E. Baly, a German physicist, showed in 1903 that the two spectra of crypton and xenon presented 37 rays of the same intensity. According to him these rays must come from a heavier gas of the same group which came along with the other gases. Rudolf Schmidt lately made some new researches which seem to show that xenon is not a simple gas, but is a mixture of several gases. One of its components he was able to separate, and he measured a part of its spectrum in the ultra-violet region. Under the action of the electric discharge, the new gas glows with a fine green light. Longer electric sparks, on the contrary, give the gas a bluish-red color.

Researches upon selenium have been made by Oechsner de Coninch and are described in a paper presented at the Académie des Sciences. When selenious acid is reduced by means of a solution of glucose, there is produced a brick-red amorphous variety of selenium. This variety of the body, whose properties were observed by the author, dissolves slowly in concentrated sulphuric acid, forming sulphoxide of selenium, $SeSO_3$. At the end of a certain time the sulphoxide deposits free selenium according to the following reaction: $SeSO_3 + H_2O = Se + H_2SO_4$. The selenium which is deposited under the conditions differs from the selenium which was used in the first place, having the following characteristics: It is of a brown color and is sometimes light and at other times dark. It does not become fluorescent, even for a short time, by exposing to diffused light. Again, it is not agglomerated after a long time and is not transformed into a viscous mass adhering to the surface of the flask. On contact with bisulphide of carbon it is not found to undergo a transformation of its physical state. Furthermore, he finds that it is dissolved but slightly after a long time in this solvent. When exposed to sunlight it is only very slowly transformed into amorphous and pulverulent black selenium. To sum up, the selenium which is separated from the sulphoxide seems to constitute a stable variety. It is interesting to remark that the selenium which entered in a certain form in the $SeSO_3$ combination, comes out of it in a different form.

Researches upon an albumen extracted from fish eggs form the subject of a paper read by L. Hugounenq, and he also makes comparison with the albumen taken from the yolk of hen's eggs. The author prepared for some time past an albumen which he succeeded in extracting from the eggs of the fish *Clupea harengus*, and he calls this matter clupeovine. By the hydrolysis of this substance under the influence of dilute sulphuric acid brought to the boiling point he forms certain products. Completing his former researches, he finds that the products obtained in this case are, independently of arginine, histidine, and lysine, it furnishes tyrosine, leucine, amino-valeric acid, alanine, serine, phenylamine, and aspartic acid. He could not find with certitude in these products the presence of glycocol and glutamic acid, perhaps on account of the small quantity of the material he possessed, this being but 4,800 grains. It is interesting to compare these results with what is obtained by hydrolysis of the yolk of an ordinary egg, which he carried out not long ago, as well as Abderhalden and Hunter. According to all these researches, the ordinary yolk furnishes also arginine, histidine, lysine, leucine, tyrosine, alanine, aspartic acid, phenyl-alanine, and proline, with small quantities of glycocol. In the case of birds and fish, the albumen of the yolk is therefore made up of the same materials according to proportions which are comparable, if not very close for the two kinds. The molecules seem thus to be elaborated on the same plan. On the contrary, in the hen's egg we find differences in the proteic bodies which make up the white and the yolk. Thus the albumen of the white of the egg gives upon hydrolysis more arginine (2.14 per cent) than the yolk (1.0 per cent). Histidine, which is rather abundant among the destruction products of the yolk, does not seem to be formed when the white is decomposed. This latter furnishes white and crystalline nitrous compounds which the author succeeds in separating.

ELECTRICAL NOTES.

Niblett claimed that the cellular construction of storage battery electrodes gave them the peculiar property of automatically regulating their own internal resistance, for if the cell be charged at too high a rate, or when it would be on the point of becoming fully charged, the gas would tend to drive the electrolyte from the pores of the elements, and itself to remain imprisoned therein, thereby largely increasing the internal resistance. At the same time he claimed that as the discharge proceeded the occluded gas re-entered into chemical combination, and allowed the liquid to refill the pores and expose more active surface. Nothing is said about the occluded gas lowering the potential, and another serious defect in this earlier Niblett cell was the high internal resistance caused principally by the use of a porous pot, which renders it useless for central station work. The manufacturers claim, however, to have overcome this difficulty in their latest type by using a porous pot of very low resistance. In this later type the negative is a true network consisting of granules of active matter, or of a mixture of active matter and diatomaceous earth, thus avoiding the isolated pockets. In the positive, the principal improvement is the use of a conducting rod having a very large surface for contact with the active material, which further lowers the resistance.

The most prominent developments in electrical work during the last ten years have been in power transmission, traction, and lighting. As to the first, power transmission has naturally been of little importance where coal is cheap and water power almost non-existent. As to the traction, the development of electric street railways was hampered by legislation, which was not remedied until 1905. On the opening up of electric traction in 1895 it was found that practically no British electrical engineers were prepared to supply either the car or generating equipments, and one line after another was equipped with American motors, trucks, controllers, generators, switchboards and even engines. While some English electrical engineers a few years ago were trying to prove that electric traction on main line railways was not feasible, German and American firms were using their endeavors to make it so. It is not the place here to enter into the vast amount of experimental work done abroad, the various three-phase and single-phase systems that have been devised, not one of which has been seriously tackled here, but the grim humor of the joke is that many of the Continental firms have been undertaking the work with the express object of securing the British main line contracts. By the very nature of the case the British main lines with their much greater volume of traffic between largely populated towns are just the very ones where main line electric traction should be first successful, and where it will undoubtedly soon come.

One of the most recent projects in France is that of securing a large amount of electric power for the city of Paris and elsewhere by a hydro-electric station of unusually large size to be erected upon the Rhone. In this way it is expected to secure not less than 100,000 horse-power, and a pole line working at a very high tension would be run to Paris. This project is perhaps nearer being realized than may be supposed. Engineer Mahl has recently drawn up a complete set of plans in which he shows the method of operating the power plant and the advantages which would be secured from it. This project has been approved by the Government Road and Bridge School and the National Electrotechnical Society. At present it has more than ordinary interest on account of the problem which the Paris municipality is considering as to how to obtain the supply of current for the city, seeing that several of the leading concessions for electric plants will expire in the near future. Upon the Rhone the work to be carried out would comprise the building of a dam below Fort de l'Ecluse and the formation in the Callonges plain of a lake containing two million cubic yards. From here would lead two underground canals having 2½ miles length and affording a head of water of about 230 feet which the engineers estimate will give the 100,000 horse-power above mentioned. As regards the power transmission from the hydraulic plant, this would be carried out on a pole line working at 65,000 volts. The dynamos of the station are to be driven by turbines of 10,000 horse-power. It is calculated that for the city of Paris there would result an economy of $4,000,000 per year.

Electric traction as a substitute for steam locomotives on railroads presents an important problem in Switzerland, where water power is available. The Federal Council of that country appointed a special commission made up of railroad and electrical engineers, which was called upon to examine the subject from all points of view and to present a report. This report has an especial value, because it is the economic question which is to decide the matter in Switzerland. In the case of many railroad lines which have been "electrified" up to the present time, the adoption of electricity was indicated by some particular technical, hygienic or esthetic requirement, such as the need of greater acceleration in starting the trains, obtaining higher speeds, mounting heavy grades, the prevention of smoke and cinders, or the like. But in the case of Switzerland, on the contrary, it was simply a question whether electric power would prove more economical. Prof. Wyssling, who was the secretary of the commission, reported that the main point to be considered was the amount of power which could be obtained for the purpose in Switzerland. He estimated that the total amount of electrical energy needed by the Swiss railroads would be 1,200,000 horse-power-hours. Calculating an efficiency of 40 per cent from the water-wheels to the electric locomotives, he estimated that about 3,000,000 horse-power-hours must be provided in the hydraulic plants. This is 125,000 horse-power during a day of twenty-four hours. No doubt this amount of power can be secured, but it may be necessary to transmit it for some distance, and it is advisable to determine if a smaller amount will not suffice. One way to do this is to devise a method of utilizing the power lost on down grades, which are numerous in a mountainous country like Switzerland. Prof. Wyssling recommends further study of this question.—Western Electrician.

ENGINEERING NOTES.

A practical drawback of the gas engine, and one that cannot be overcome by the highest engineering skill because inherent in the cycle, is the lack of overload capacity in gas engines and the fact that the range of economical load is limited to only a fraction of the total. This is by no means as small as is usually held. This unfortunate characteristic of the gas engine, that is, its lack of overload capacity, often militates against its adoption and is especially felt when operating urban and interurban railway plants. It can be compensated either by a storage battery of sufficient capacity or by an auxiliary steam turbine system as proposed by Stott, or by the installation of spare gas engine units with a corresponding equipment for gas storage or instantaneous generation. There is no prime mover that lends itself better to the latter application, especially as, since the employment of compressed air, gas engines can be started quite as easily as steam engines.

There are at least two outstanding fundamental factors in the economics of the design of civil engineering work: there is the necessity for economy in the first cost from the point of view of the minimum charge of interest on capital expended, and there is the necessity for prudence from the point of view of sufficiency coupled with the cost of maintenance. We would have young civil engineers especially remember that in the selection and approval of materials it is essential that there shall be exercise of such sound judgment as will have the certain effect of securing durable work—that is, work that will not be unduly affected by the ravages of time and tear and wear and decay. The unfortunate necessity of having continually to spend money in repair and renewal must be constantly borne in mind, and the civil engineer does not do his duty if in scheming, designing, and constructing work he fails to realize and constantly remember that things wear out, and that it is essential that he should insure that in all reasonable time there shall be the least possible expenditure in maintenance. It is the absolute duty of the civil engineer to devote himself to consideration of the means by which the everlasting burden of perpetual expenditure in maintenance may be minimized, and he must have great regard to practicability, and so design and construct work that its upkeep and renewal may be readily accomplished with the least possible inconvenience and at the least possible cost. It is, of course, impossible so to design and construct works that there will be no need for any expenditure in maintenance and renewal; but I contend that by the exercise of reasonable discretion in the design, care in the selection of materials, and thoroughness in execution, it is possible to insure that expenditure being at the minimum.

In Germany, a small country of four-fifths the size of Texas, there are to-day in the iron and coal industry alone in active service or in contemplation 136 gas blowing engines with 161,300 horse-power, 200 gas dynamos with 206,300 horse-power, 11 gas engine roll drives with 17,000 horse-power, and 47 coke oven dynamos with 40,000 horse-power, besides four engines with 1,500 horse-power, for other purposes, or a total of about 400 large gas engines with a combined capacity of 420,000 horse-power. This much we learn from one of the most valuable papers considered at the last meeting of the American Mechanical Engineers, the figures being cited by Herr F. E. Junge, of Berlin, who traced in a most interesting manner the evolution of gas power. A note of regret is sounded in this paper that the various attempts to improve on the working process as carried out in standard gas engines (as by prolonged expansion, compounding, and water injection) have proved to be entries on the wrong side of the balance sheet. The drawbacks common to all of these so-called improvements are increased bulk, weight, first cost, and negative work expanded. Since the majority of failures of gas power plants have been due to the fact that the engines selected were too small for the maximum duty which they were expected to perform, the author is of opinion that the rating of gas engines should be standardized and the public should be advised by the manufacturers that for a service with heavy overloads, such as occur, for instance, when driving rolling mills, the capacity of gas engines must be considerably larger than that of steam engines. Despite the drawbacks outlined he proceeds to assure us that it would be wrong to conclude that the present type of gas prime movers is not on a high level of excellence, as an economical and reliable machine. Just as the steam turbine cannot be regarded as having reached its highest state of perfection and yet is a commercial engine of the greatest possibilities, so it is with the gas engine. After having passed out of the costly experimental state, and after having reached a condition of standard design, its manufacture is now as profitable to the engine builder as its application is to the power consumer. The variety of earlier forms has now been reduced to

two classes: (1) the double-acting tandem four-cycle engine, and (2) the double-acting two-cycle engine. The single-acting type of each is only applicable in the smaller sizes. Each type has its disadvantages and each its special field of application.

TRADE NOTES AND FORMULÆ.

Sterlin.—A white metal resembling silver has found its way on the market under the name of sterlin, which has been found to contain 68.52 per cent of copper, 12.84 per cent of zinc, 17.88 per cent of nickel, 0.76 per cent of iron, and traces of lead. Silver and manganese were absent. Manganese is very useful for introducing iron into such alloys. If, says Sperry, an alloy consisting of 4 parts of iron and 1 part of manganese is smelted together with copper and nickel, the iron combines homogeneously with the latter, and an alloy free from hard lumps is formed, while the manganese disappears entirely after from one to four meltings.

Preparation of Finnish Wood Paint.—Three mixtures are necessary for preparing Finnish wood paint. They are prepared separately and then combined:

1. Dissolve 5 parts ordinary rye flour in 15 parts cold well water and stir well.
2. Dissolve 2 parts white vitriol in 45 parts boiling water.
3. Dissolve 1½ parts rosin in 10 parts train oil, hot.

Carefully mix the first liquid with the second by stirring; then add the last, stirring as before.

Swedish paint for old wood is made as follows: Boil 34 parts by weight of water, 1 part green vitriol, 2 parts of colcothar, 2 parts linseed oil, 2 parts salt. Paint the wood with this mixture while hot.

To Render Corks Impermeable.—Referring to the manufacture of impenetrable corks for vessels containing extracts, we would draw attention to the following process, taken from the Deutsche Destillateurzeitung, for making corks absolutely impermeable: 5 per cent of glycerine is added to a 5 per cent solution of gelatine and the corks, which, of course, must be properly weighted, allowed to remain for several hours in the liquid. Care must be taken that the temperature of the bath is warm enough to retain the gelatine solution in a fluid condition. The gelatine fills up the pores of the corks, while the glycerine serves to keep the latter elastic. The corks remain in the bath till they are completely saturated, and are then allowed to dry in the ordinary way, no special method being necessary. Tightly-fitting corks, elastic and at the same time impenetrable even by gases, can be obtained by this process.

Imitation Patina.—The best method of obtaining a coating resembling patina, according to the Metallarbeiter, Vienna, is to immerse the article in a solution of nitrate of copper, and then to place it while still wet in a chamber containing an abundance of carbonic acid. The fermenting room of a brandy distillery is specially adapted for this purpose, as, besides containing carbonic acid, it has a rather high temperature, which materially aids the formation of the coating. In this case the development of the green incrustation may be observed from day to day; if after about a week the object has not yet obtained the proper color, it must be again dipped in the above solution, and this operation repeated till the desired shade has been acquired. As the formation of patina under these conditions proceeds in the same way as in the open air but more rapidly, a handsome and permanent coating can be produced by this means.

Practical Directions for Making Vinegar Essences.—In preparing table vinegar pure 80 per cent commercial acetic acid is taken as the basis.

Wine-vinegar Essence.—I. To 10 parts by weight of cognac oil, 20 parts acetic ether, and 20 parts Maitrank (May-wine = wine flavored with woodruff) essence, sufficient alcohol is added to make up 1,000 parts, and one part of this mixture is mixed with 90 parts of 80 per cent acetic acid. II. Cognac oil 3 parts by weight, acetic ether 50 parts, pear ether 50 parts, alcohol q. s. ad 500 parts. About 2 per cent of this mixture should be added to the acetic acid. III. In many cases pure 80 per cent acetic acid, colored with a solution of sugar color in acetic acid, is sold as wine-vinegar essence.

Tarragon-vinegar Essence.—I. 20 parts, by weight, of tarragon oil and 30 parts Maitrank essence are mixed with sufficient alcohol to make up 2,000 parts. About 1 per cent of this mixture is added to 90 per cent acetic acid. II. 1,000 parts by weight of vinegar, to which 20 parts alcohol have been added, are digested with 10 parts fresh tarragon herbs, 10 parts laurel leaves, and 1 part each of nutmeg and cloves. This concentrated aroma is also added to the acetic acid.

Medicated Vinegar Essence.—I. Herb. Dracuculi rec. 200, Fruct. Anethi rec. 200, Herb. Achilleæ moschat. 25, Fol. Lauri 25. These spices are well moistened with diluted alcohol, and after 24 hours 5,000 parts acetic acid (80 per cent) are poured over it. After five days it is squeezed off and filtered. This aroma is then mixed with 80 per cent acetic acid as required. II. 4 parts by weight of tarragon oil, 8 parts oil of celery, 4 parts pepper-wort oil, 5 parts oil of parsley, and 30 parts Maitrank essence; add alcohol to make up 1,000 parts. One part of this mixture is added to 1,000 parts of the acid. As a coloring agent for vinegar essences a solution of sugar color in acetic acid or for hotels (which frequently prefer red colored table vinegar) a solution of cochineal red in concentrated acetic acid is employed.

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